



(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention  
of the grant of the patent:  
**06.10.2004 Bulletin 2004/41**

(51) Int Cl.<sup>7</sup>: **G01N 33/53, G01N 33/537,  
G01N 33/542, G01N 33/543**

(21) Application number: **95939892.6**

(86) International application number:  
**PCT/US1995/014659**

(22) Date of filing: **13.11.1995**

(87) International publication number:  
**WO 1996/015452 (23.05.1996 Gazette 1996/23)**

(54) **METHODS FOR AIDING IN THE DIAGNOSIS OF ALZHEIMER'S DISEASE BY MEASURING  
AMYLOID-BETA PEPTIDE (X- 41) AND TAU**

VERFAHREN ZUR UNTERSTÜTZUNG DER DIAGNOSE DER ALZHEIMERSCHEN KRANKHEIT  
DURCH MESSUNG DER AMYLOID-BETA-PEPTIDE(X GROESSER ALS ODER GLEICH 41) UND  
TAU

METHODE D'ASSISTANCE AU DIAGNOSTIC DE LA MALADIE D'ALZHEIMER PAR MESURE DU  
PEPTIDE AMYLOIDE-BETA (X- 41) ET DE LA PROTEINE TAU

(84) Designated Contracting States:  
**AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL  
PT SE**

(56) References cited:  
**EP-A- 0 444 856 WO-A-94/10569**

(30) Priority: **14.11.1994 US 339141  
07.04.1995 US 419008**

(43) Date of publication of application:  
**03.09.1997 Bulletin 1997/36**

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## Description

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

[0001] The present invention relates generally to methods for diagnosing or monitoring Alzheimer's disease. More particularly, the present invention relates to measuring the amount of tau protein and/or the amount of  $\beta$  amyloid peptide ( $x \geq 41$ ) in patient fluid samples and using these amounts as a diagnostic indicator.

[0002] Alzheimer's disease (AD) is a degenerative brain disorder characterized clinically by progressive loss of memory, cognition, reasoning, judgment and emotional stability that gradually leads to profound mental deterioration and ultimately death. AD is a very common cause of progressive mental failure (dementia) in aged humans and is believed to represent the fourth most common medical cause of death in the United States. AD has been observed in all races and ethnic groups worldwide and presents a major present and future public health problem. The disease is currently estimated to affect about two to three million individuals in the United States alone. AD is at present incurable. No treatment that effectively prevents AD or reverses its symptoms or course is currently known.

[0003] The brains of individuals with AD exhibit characteristic lesions termed senile plaques, and neurofibrillary tangles. Large numbers of these lesions are generally found in several areas of the human brain important for memory and cognitive function in patients with AD. Smaller numbers of these lesions in a more restricted anatomical distribution are sometimes found in the brains of aged humans who do not have clinical AD. Senile plaques and amyloid angiopathy also characterize the brains of individuals beyond a certain age with Trisomy 21 (Down's Syndrome) and Hereditary Cerebral Hemorrhage with Amyloidosis of the Dutch-Type (HCHWA-D). At present, a definitive diagnosis of AD usually requires observing the aforementioned lesions in the brain tissue of patients who have died with the disease or, rarely, in small biopsied samples of brain tissue taken during an invasive neurosurgical procedure. The principal chemical constituent of the senile plaques and vascular amyloid deposits (amyloid angiopathy) characteristic of AD and the other disorders mentioned above is an approximately 4.2 kilodalton (kD) protein of about 39-43 amino acids designated the amyloid- $\beta$  peptide ( $A\beta$ ) or sometimes  $\beta$ AP,  $A\beta$ P or  $\beta$ /A4.  $A\beta$  was first purified and a partial amino acid sequence reported in Glenner and Wong (1984) Biochem. Biophys. Res. Commun. 120:885-890. The isolation procedure and the sequence data for the first 28 amino acids are described in U.S. Patent No. 4,666,829. Forms of  $A\beta$  having amino acids beyond number 40 were first reported by Kang et al. (1987) Nature 325:733-736.

[0004] Roher et al. (1993) Proc. Natl. Acad. Sci. USA 90:10836-840 showed that  $A\beta$ (1-42) is the major constituent in neuritic plaques (90%) with significant amounts of isomerized and racemized aspartyl residues. The authors also showed that  $A\beta$ (17-42) also predominates in diffuse plaques (70%), while  $A\beta$ (1-40) is the major constituent in the meningovascular plaques, comprising 60% of the total  $A\beta$  and, in parenchymal vessel deposits  $A\beta$ (1-42) represents 75% of the total  $A\beta$ . Iwatsubo et al. (1994) Neuron 13:45-53 showed that  $A\beta$ 42(43)-positive senile plaques are the major species in sporadic AD brain.

[0005] Molecular biological and protein chemical analyses conducted during the last several years have shown that  $A\beta$  is a small fragment of a much larger precursor protein, referred to as the  $\beta$ -amyloid precursor protein (APP), that is normally produced by cells in many tissues of various animals, including humans. Knowledge of the structure of the gene encoding APP has demonstrated that  $A\beta$  arises as a peptide fragment that is cleaved from the carboxy-terminal end of APP by as-yet-unknown enzymes (proteases). The precise biochemical mechanism by which the  $A\beta$  fragment is cleaved from APP and subsequently deposited as amyloid plaques in the cerebral tissue and in the walls of cerebral and meningeal blood vessels is currently unknown.

[0006] Several lines of evidence indicate that progressive cerebral deposition of  $A\beta$  plays a seminal role in the pathogenesis of AD and can precede cognitive symptoms by years or decades (for review, see Selkoe (1994) J. Neuropath. and Exp. Neurol. 53:438-447 and Selkoe (1991) Neuron 6:487). The single most important line of evidence is the discovery in 1991 that missense DNA mutations at amino acid 717 of the 770-amino acid isoform of APP can be found in affected members but not unaffected members of several families with a genetically determined (familial) form of AD (Goate et al. (1991) Nature 349:704-706; Chartier Harlan et al. (1991) Nature 353:844-846; and Murrell et al. (1991) Science 254:97-99). Suzuki et al. (1994) Science 264:1336-1340 showed that in persons with the 717 mutation, there is a higher percentage of  $A\beta$ (1-42) than  $A\beta$ (1-40).

[0007] In addition, a double mutation changing lysine<sup>595</sup>-methionine<sup>596</sup> to asparagine<sup>595</sup>-leucine<sup>596</sup> (with reference to the 695 isoform) found in a Swedish family was reported in 1992 (Mullan et al. (1992) Nature Genet 1:345-347) and is referred to as the Swedish variant. Genetic linkage analyses have demonstrated that these mutations, as well as certain other mutations in the APP gene, are the specific molecular cause of AD in the affected members of such families. In addition, a mutation at amino acid 693 of the 770-amino acid isoform of APP has been identified as the cause of the  $A\beta$  deposition disease, HCHWA-D, and a change from alanine to glycine at amino acid 692 appears to cause a phenotype that resembles AD in some patients but HCHWA-D in others. The discovery of these and other

mutations in APP in genetically based cases of AD argues that alteration of APP and subsequent deposition of its A $\beta$  fragment can cause AD.

[0008] Neurofibrillary tangles are composed mainly of the microtubule protein, tau. Z.S. Khachaturian (1985) Arch. Neurol. 42:1097-1105. Recent studies have shown that tau is elevated in the CSF of Alzheimer's disease patients. M. Vandermeeren et al. (1993) J. Neurochem. 61:1828-1834.

[0009] Despite the progress which has been made in understanding the underlying mechanisms of AD, there remains a need to develop methods for use in diagnosis of the disease. While the level of tau is of some help in diagnosing Alzheimer's disease (M. Vandermeeren et al., *supra*) more markers, and more specific markers would be helpful. It would be further desirable to provide methods for use in diagnosis of A $\beta$ -related conditions, where the diagnosis is based at least in part on detection of A $\beta$  and related fragments in patient fluid samples. Specific assays for A $\beta$  detection should be capable of detecting A $\beta$  and related fragments in fluid samples at very low concentrations as well as distinguishing between A $\beta$  and other fragments of APP which may be present in the sample.

## 2. Description of the Background Art

[0010] Glenner and Wong (1984) Biochem. Biophys. Res. Commun. 120:885-890 and U.S. Patent No. 4,666,829, are discussed above. The '829 patent suggests the use of an antibody to the 28 amino acid A $\beta$  fragment to detect "Alzheimer's Amyloid Polypeptide" in a patient sample and diagnose AD. No data demonstrating detection or diagnosis are presented.

[0011] Numerous biochemical electron microscopic and immunochemical studies have reported that A $\beta$  is highly insoluble in physiologic solutions at normal pH. See, for example, Glenner and Wong (1984) Biochem. Biophys. Res. Commun. 122:1131-1135; Masters et al. (1985) Proc. Natl. Acad. Sci. USA 82:4245-4249; Selkoe et al. (1986) J. Neurochem. 46:1820-1834; Joachim et al. (1988) Brain Research 474:100-111; Hilbich et al. (1991) J. Mol. Biol. 218:149-163; Barrow and Zagorski (1991) Science 253:179-182; and Burdick et al. (1992) J. Biol. Chem. 267:546-554. Furthermore, this insolubility was predicted by and is consistent with the amino acid sequence of A $\beta$  which includes a stretch of hydrophobic amino acids that constitutes part of the region that anchors the parent protein (APP) in the lipid membranes of cells. Hydrophobic, lipid-anchoring proteins such as A $\beta$  are predicted to remain associated with cellular membranes or membrane fragments and thus not be present in physiologic extracellular fluids. The aforementioned studies and many others have reported the insolubility in physiologic solution of native A $\beta$  purified from AD brain amyloid deposits or of synthetic peptides containing the A $\beta$  sequence. The extraction of A $\beta$  from cerebral amyloid deposits and its subsequent solubilization has required the use of strong, non-physiologic solvents and denaturants. Physiologic, buffered salt solutions that mimic the extracellular fluids of human tissues have uniformly failed to solubilize A $\beta$ .

[0012] Separate attempts to detect APP or fragments thereof in plasma or CSF have also been undertaken. A large secreted fragment of APP that does not contain the intact A $\beta$  region has been found in human cerebrospinal fluid (Palmert et al. (1989) Proc. Natl. Acad. Sci. USA 86:6338-6342; Weidemann et al. (1989) Cell 57:115-126; Henriksson et al. (1991) J. Neurochem. 56:1037-1042; Palmert et al. (1990) Neurology 40:1028-1034; and Seubert et al. (1993) Nature 361:260-263) and in plasma (Podlisny et al. (1990) Biochem. Biophys. Res. Commun. 167:1094-1101). The detection of fragments of the carboxy-terminal portion of APP in plasma has also been reported (Rumble et al. (1989) N. Engl. J. Med. 320:1446-1452), as has the failure to detect such fragments (Schlossmacher et al. (1992) Neurobiol. Aging 13:421-434).

[0013] Despite the apparent insolubility of native and synthetic A $\beta$ , it had been speculated that A $\beta$  might occur in body fluids, such as cerebrospinal fluid (CSF) or plasma (Wong et al. (1984) Proc. Natl. Acad. Sci. USA 92:8729-8732; Selkoe (1986) Neurobiol. Aging 7:425-432; Pardridge et al. (1987) Biochem. Biophys. Res. Commun. 145:241-248; Joachim et al. (1989) Nature 341:226-230; Selkoe et al. (1989) Neurobiol. Aging 10:387-395).

[0014] Several attempts to measure A $\beta$  in CSF and plasma have been reported by both radioimmunoassay methods (WO90/12870 published November 1, 1990) and sandwich ELISAs (Wisniewski in *Alzheimer's Disease*, eds. Becker and Giacobini, Taylor and Francis, N.Y. pg. 206, 1990; Kim and Wisniewski in *Techniques in Diagnostic Pathology*, eds. Bullock et al., Academic Press, Boston pg. 106; and WO90/12871 published November 1, 1990). While these reports detected very low levels of A $\beta$  immunoreactivity in bodily fluids, attempts to directly purify and characterize this immunoreactivity further and determine whether it represented A $\beta$  were not pursued, and the efforts were abandoned. The possibility of A $\beta$  production by cultured cells was neither considered nor demonstrated.

[0015] Retrospectively, the inability to readily detect A $\beta$  in bodily fluids was likely due to the presence of amyloid precursor fragments with overlapping regions or fragments of A $\beta$  that obscured measurements and to the lack of antibodies completely specific for intact A $\beta$ . This is presumably because the antibodies used by both groups would cross-react with other APP fragments containing part of A $\beta$  known to be present in CSF thereby interfering with the measurement, if any, of intact A $\beta$ . These difficulties have been overcome with the use of monoclonal antibodies specific to an epitope in the central junction region of intact A $\beta$  (Seubert et al. (1992) Nature 359:325-327).

[0016] Seubert et al. (1992) Nature 359:325-327 and Shoji et al. Science (1992) 258:126-129 provided the first biochemical evidence for the presence of discrete A $\beta$  in bodily fluids. Vigo-Pelfrey et al. (1993) J. Neurochem. 61: 1965-1968 reported the identification of many A $\beta$  species in cerebrospinal fluid.

## SUMMARY OF THE INVENTION

[0017] The present invention provides methods useful for aiding in the diagnosis and monitoring of A $\beta$ -related conditions in patients, where the methods rely on the specific detection in patient fluid samples of one or more soluble A $\beta$  or soluble A $\beta$  fragments having amino acid residues beyond number 40 in their carboxy-terminal end. These peptides are designated "A $\beta$ (x $\geq$ 41)" (A $\beta$  from amino acid number "x" to an amino acid greater than or equal to amino acid number 41). In one embodiment, the measured peptides belong to the class of A $\beta$ (x $\geq$ 41) that contain at least amino acids 13-41.

[0018] For the diagnosis and monitoring of A $\beta$ -related conditions, the amount of the aforementioned peptides in a patient fluid sample, especially cerebrospinal fluid (CSF), is measured and compared with a predetermined value, such as an indicator value (in the case of diagnosis) or a prior patient value (in the case of monitoring). In the case of diagnosis, measured amounts of A $\beta$ (x $\geq$ 41) which are above the indicator value are considered to be a strong indication that the patient is not suffering from AD or other A $\beta$ -related condition. However, this information may also be considered together with other factors in making a determinative diagnosis. Measured amounts of A $\beta$ (x $\geq$ 41) which are at or below the indicator value are considered to be a positive indication that the patient may be suffering from AD or other A $\beta$ -related condition. The low A $\beta$ (x $\geq$ 41) status of the tested individual usually will not by itself be considered a determinative diagnostic of an A $\beta$ -related condition, but instead will be considered together with other accepted clinical symptoms of A $\beta$ -related conditions in making a diagnosis. In cerebrospinal fluid, an indicator value of about 0.5 ng/ml is useful.

[0019] In a particular aspect, the present invention provides specific binding assays which are useful for detecting soluble A $\beta$ (x $\geq$ 41) in fluid samples and which may be employed in patient diagnostic and monitoring methods just described. Specific binding assays according to the present invention employ two binding substances specific for different epitopes or determinant sites on the A $\beta$ (x $\geq$ 41) molecule. One epitope or site is generally not found on other fragments or degradation products of the amyloid- $\beta$  precursor protein (APP), so as to avoid cross-reaction with those fragments.

Particularly useful are antibodies which recognize a junction region within A $\beta$ , where the junction region is located about the site of normal proteolytic cleavage of APP between residues Lys<sup>16</sup> and Leu<sup>17</sup> (Esch et al. (1990) Science 248:492-495 and Anderson et al. (1991) Neuro. Science Lett. 128:126-128), typically spanning amino acid residues 13 to 26. The other epitope or site contains at least one amino acid beyond amino acid number 40 of A $\beta$  that is essential for recognition, but does not cross-react with A $\beta$  or A $\beta$  fragments whose carboxy-terminal amino acid is number 40 or less. Exemplary specific binding assays include two-site (sandwich) assays in which the capture antibody is specific for the junction region of A $\beta$ , as just described, and a second detectable antibody is specific for an epitope or site containing at least one A $\beta$  amino acid beyond number 40. In particular, the second antibody can be produced by immunization with a hapten containing A $\beta$  amino acids 33-42.

[0020] This invention also provides methods for aiding in the diagnosis or monitoring of Alzheimer's disease in a patient involving measurements of both A $\beta$ (x $\geq$ 41) and the microtubule protein tau. The methods involve measuring the amount of one or more soluble A $\beta$ (x $\geq$ 41) in a patient sample; comparing the measured amount with a predetermined amount of soluble A $\beta$ (x $\geq$ 41); measuring the amount of tau in a patient sample; comparing the measured amount with a predetermined amount of said tau; and assessing patient status based on a difference between the measured and predetermined amounts of A $\beta$ (x $\geq$ 41) and tau. Again, the predetermined amount can be an indicator value or a prior patient value. A measured amount at or below the A $\beta$ (x $\geq$ 41) indicator value and at or above the tau indicator value provides a positive indication in the diagnosis of Alzheimer's disease, and wherein a measured amount above the of the A $\beta$ (x $\geq$ 41) indicator value and below the tau indicator value provides a negative indication in the diagnosis of Alzheimer's disease. Indicator values in the CSF of about 0.5 ng/ml for A $\beta$ (x $\geq$ 41) and about 0.3 ng/ml for tau are useful.

[0021] This invention also provides kits for aiding in the diagnosis of Alzheimer's disease. The kits include a binding substance that binds A $\beta$ (x $\geq$ 41) but that does not bind to A $\beta$ ( $\leq$ 40) and a binding substance that binds to tau. In one embodiment, the kit contains four antibodies: a) an un-labeled antibody that binds to the junction region of A $\beta$ ; b) a detectably labelled antibody that binds to an epitope containing amino acids beyond number 40 in A $\beta$ ; c) an un-labelled antibody that binds to tau; and d) a detectably labelled antibody that binds to tau.

[0022] In another aspect, the present invention provides a system for detecting one or more soluble A $\beta$ (x $\geq$ 41) in a fluid sample. The system includes a first binding substance, typically an antibody, specific for an epitope in a junction region of A $\beta$ , as described above, and a second binding substance, typically an antibody, specific for an epitope of A $\beta$  containing an amino acid beyond amino acid number 40 of A $\beta$  at the carboxy-terminus essential for recognition. The first binding substance is an anti-A $\beta$  antibody bound to a solid phase, while the other is a reporter antibody against the A $\beta$  carboxy-terminus. The reporter antibody can, itself, be labeled, or can be detectable by another antibody (e.g., a

rabbit antibody recognizable by labeled or enzyme-conjugated anti-rabbit antibodies.) The system can further include substrate for an enzyme label. The system is useful in performing enzyme-linked immunosorbent assays (ELISA) having high specificity and sensitivity for the detection of  $A\beta(x \geq 41)$  in fluid samples.

[0023] In another aspect, this invention provides methods for screening a compound to determine its ability to alter the amount of  $A\beta(x \geq 41)$  in the CSF. The methods involve measuring a first amount of soluble  $A\beta(x \geq 41)$  in the CSF of a non-human animal used as a model of Alzheimer's disease; administering the compound to the non-human animal; measuring a second amount of soluble  $A\beta(x \geq 41)$  in the CSF of the non-human animal; and comparing the first amount with the second amount. The difference indicates whether the compound increases  $A\beta(x \geq 41)$  in the CSF, in which case it might be useful in the treatment of Alzheimer's; or decreases the amount, in which case the compound might aggravate or hasten Alzheimer's. The non-human animal preferably is a mammal, more preferably a rodent, and most preferably a mouse.

[0024] In another aspect, this invention provides methods for screening a compound to determine its ability to alter the amount of both  $A\beta(x \geq 41)$  and tau in the CSF involving measuring a first amount of one or more soluble  $A\beta(x \geq 41)$  in the CSF of a non-human animal used as a model of Alzheimer's disease; measuring a first amount of tau in the CSF of the non-human animal; administering the compound to the non-human animal; measuring a second amount of said one or more soluble  $A\beta(x \geq 41)$  in the CSF of the non-human animal; measuring a second amount of tau in the CSF of the non-human animal; and comparing the first amounts with the second amounts, the difference indicating whether the compound increases, decreases, or leaves unchanged the amount of soluble  $A\beta(x \geq 41)$  and increases, decreases, or leaves unchanged the amount of tau in the CSF. The information is useful, as above, to identify compounds that might be useful in treating Alzheimer's or that might aggravate or hasten Alzheimer's. The non-human animal preferably is a mammal, more preferably a rodent, and most preferably a mouse.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0025]

Fig. 1 shows the results of ELISA assays using antibody 266 (directed to the  $A\beta$  junction region) and antibody 277/2 (directed to  $A\beta$  amino acids 33-42) to detect  $A\beta(42)$ , but not  $A\beta(28)$ ,  $A\beta(38)$ , or  $A\beta(40)$ .

Fig. 2 shows the amounts of  $A\beta(x \geq 41)$  in CSF of control patients (C) and AD patients (AD) in Group A as detected by ELISA.

Fig. 3 shows the amounts of  $A\beta(x \geq 41)$  in CSF of AD patients (AD), non-Alzheimer's neurological controls (NC) and controls (C) in Group B as detected by ELISA.

Fig. 4 shows the amounts of  $A\beta(x \geq 41)$  in CSF of AD patients (AD), non-Alzheimer's neurological controls (ND) and non-demented controls (NC) as detected by ELISA.

Fig. 5 shows the amounts of tau in CSF of Alzheimer's disease patients (AD), non-Alzheimer's neurological controls (ND) and non-demented control patients (NC).

Fig. 6 shows the amounts of  $A\beta(x \geq 41)$  and tau in CSF of Alzheimer's disease patients (AD), non-Alzheimer's neurological controls (ND) and non-demented controls (NC). Data from Figures 4 and 5 are combined to illustrate the effect of simultaneous consideration of the two measures in discriminating the AD group. Lines indicate optimized cutoffs. The high tau/low  $A\beta(x \geq 41)$  quadrant contains AD patients with only a single exception (21/22 patients) whereas the low tau/high  $A\beta(x \geq 41)$  quadrant contains only control individuals.

## DESCRIPTION OF THE SPECIFIC EMBODIMENTS

[0026] The present invention results at least in part from the discovery that the cerebrospinal fluid ("CSF") of individuals suffering from Alzheimer's disease generally contains  $A\beta(x \geq 41)$  in amounts which are in the very low end of the normal range present in the CSF of non-Alzheimer's individuals and, in particular, below about 0.5 ng/ml. This discovery is surprising because the bulk of  $A\beta$  deposits in the brain tissue of persons suffering from Alzheimer's disease is  $A\beta(1-42)$ , and is significantly elevated compared to the amount of  $A\beta(1-42)$  in non-Alzheimer's individuals.

[0027] Based on this discovery the present invention provides methods for diagnosing and monitoring Alzheimer's disease. According to one method, a patient sample is first obtained. The patient sample is usually a fluid sample and, preferably, cerebrospinal fluid. Then the amount of soluble  $A\beta(x \geq 41)$  in the patient sample is measured. A preferred method of measuring the amount is by using the sandwich assay described herein. The measured amount is then compared with a predetermined value, such as an indicator value in the case of diagnosis, or a prior patient value in the case of monitoring. The status of the patient is assessed based on the difference between the two amounts.

[0028] As described in more detail below, the methods of the present invention will be useful as both a positive and negative indicator of AD and other  $A\beta$ -related conditions in tested individuals. The data in the Experimental section show that individuals not suffering from Alzheimer's disease have CSF concentrations of soluble  $A\beta(x \geq 41)$  that range

from about 0.2 ng/ml to about 1.0 ng/ml. However, patients with Alzheimer's disease have CSF concentrations of soluble A $\beta$ (x $\geq$ 41) generally below 0.5 ng/ml. Therefore, a measured amount above the indicator value of about 0.5 ng/ml is a very strong negative indication of Alzheimer's disease. That is, individuals having such levels are considered to be less likely to suffer from an A $\beta$ -related condition and, in particular, Alzheimer's disease. An indicator value of 0.7 ng/ml will reduce the number of false negatives detected and is also useful as a predetermined amount. By contrast, a measured amount below the indicator value of 0.5 ng/ml is a positive indicator of Alzheimer's disease and individuals having these levels are considered to be more likely to suffer from Alzheimer's disease. An indicator value of 0.45 ng/ml reduces the number of false positives and is also useful as a predetermined value. However, since values below 0.5 ng/ml and 0.45 ng/ml are at the low end of the normal range found in non-Alzheimer individuals, a measured amount below the indicator level does not, by itself, suffice to provide a diagnosis of Alzheimer's disease. Therefore, the methods of the present invention will be useful as part of a diagnosis procedure which will also consider other known AD symptoms, such as those described in the NINCDS-ADRDA criteria (e.g., clinical dementia and memory impairment).

**[0029]** The invention also results in part from the discovery that a finding of A $\beta$ (x $\geq$ 41) in the low end of the normal range together with a finding of higher than normal amounts of tau in the CSF of an individual is a stronger positive indicator of Alzheimer's disease than either finding alone, and that a finding of high levels of A $\beta$ (x $\geq$ 41) and low levels of tau in the CSF of an individual is a very strong negative indicator of Alzheimer's disease. Thus, the combined use of these two markers appears to offer significant complementary diagnostic information.

**[0030]** Data presented in Figure 6 show that patients who exhibit high tau (above about 0.3 ng/ml) and low A $\beta$ (x $\geq$ 41) (below about 0.5 ng/ml) had a 96% likelihood of having Alzheimer's disease (22/23). Fifty-nine percent of the Alzheimer's disease patients in this study (22/37) fall into this category. Conversely, patients who exhibit low tau (below about 300 ng/ml) and elevated A $\beta$ (x $\geq$ 41) had a 100% likelihood of not having Alzheimer's disease (28/28, Figure 6). Slightly over half of the non-Alzheimer's disease subjects (28/52, 54%) fall into this category. Taken together, the combined analysis of CSF tau and A $\beta$ (x $\geq$ 41) was highly predictive of either the presence or the absence of Alzheimer's disease in slightly over half of all individuals enrolled in this study. The combined CSF tau and A $\beta$ (x $\geq$ 41) measurements were not informative in those patients that fell into the low A $\beta$ (x $\geq$ 41)/low tau group. Nevertheless, the ability of any test to aid in the inclusion or exclusion of Alzheimer's disease with high specificity and even moderate sensitivity is greatly important.

**[0031]** According to a second method of this invention, the amount of both soluble A $\beta$ (x $\geq$ 41) and tau in a patient sample is measured. One useful method of determining the amount of tau is by ELISA as described in more detail below. The measured amounts of A $\beta$ (x $\geq$ 41) and tau are then compared with pre-determined values for each. The status of the patient is assessed based on the difference between the predetermined values and the measured values.

**[0032]** As discussed below, indicator values can be calibrated based on the particular binding substance used and the particular A $\beta$ (x $\geq$ 41) and tau protein to be detected.

Calibration involves testing the binding substance against standards from individuals having an A $\beta$ -related disease and control standards from those not having such a disease.

Indicator values are selected from these results based on the numbers of false positives or false negatives the practitioner is willing to tolerate. It is expected that indicator values using different binding substances and directed against the targets described herein will be roughly the same as the indicator values described herein. Indicator values below 0.45 ng/ml for A $\beta$ (x $\geq$ 41) and above 0.4 ng/ml for tau decrease the number of false positive results; while indicator values above 0.7 ng/ml for A $\beta$ (x $\geq$ 41) and below 0.25 ng/ml for tau decreases the potential for a false indication of freedom from Alzheimer's disease.

**[0033]** If the reason for reduced CSF A $\beta$ (x $\geq$ 41) in AD is indeed secondary to ongoing plaque deposition, it could explain why a substantial number of neurological disease subjects and a few control subjects presented with low A $\beta$ (x $\geq$ 41) levels in CSF. Plaque deposition has been hypothesized to precede cognitive failure and a significant portion of these elderly non-AD subjects would be expected to develop AD within the next several years (DMA Mann et al. (1992) Neurodegeneration 1:201-215 and DL Price et al. (1991) Neurobiol Aging 12:295-312). Longitudinal studies will obviously be required to address the possibility that low A $\beta$ (x $\geq$ 41) levels are predictive of AD.

**[0034]** It was also found that levels of tau in AD CSF do not correlate with age, MMSE, total A $\beta$ , A $\beta$ <sub>42</sub>, or ApoE  $\epsilon$ 4. Although the precise reason for elevation of tau in AD remains unclear, it is likely due to the increased tau levels in AD brain tissue (S. Khatoon et. al. (1992) J Neurochem 59:750-753) combined with the ongoing degeneration of neurons in the disease.

**[0035]** The sandwich assay described in the Experimental section used antibodies raised against the junction region of A $\beta$  and against residues 33-42 of A $\beta$ . In this assay, Alzheimer's patients generally had levels of A $\beta$ (x $\geq$ 41) below 0.5 ng/ml as detected by the antibodies. The indicator value of 0.5 ng/ml is, in part, a function of the particular peptides recognized by the antibodies used as well as the peptide lot used in making the calibration. Therefore, the practitioner may base the predetermined amount on a re-calibration using reagents and protocols to be used in measuring A $\beta$ (x $\geq$ 41) in the test.

**[0036]** In addition to initial diagnosis of the A $\beta$ -related condition, the measured concentrations of A $\beta$  may be monitored

in order to follow the progress of the disease, and potentially follow the effectiveness of treatment (when such treatments become available). It would be expected that levels of A $\beta$ (x $\geq$ 41) would decrease as the disease progressed.

**[0037]** The term "amyloid- $\beta$  peptide," or "A $\beta$ " as used herein refers to an approximately 4.2 kD protein which, in the brains of AD, Down's Syndrome, HCHWA-D and some normal aged subjects, forms the subunit of the amyloid filaments comprising the senile (amyloid) plaques and the amyloid deposits in small cerebral and meningeal blood vessels (amyloid angiopathy). A $\beta$  can occur in a filamentous polymeric form (in this form, it exhibits the Congo-red and thioflavin-S dye-binding characteristics of amyloid described in connection therewith). A $\beta$  can also occur in a non-filamentous form ("preamyloid" or "amorphous" or "diffuse" deposits) in tissue, in which form no detectable birefringent staining by Congo red occurs. A portion of this protein in the insoluble form obtained from meningeal blood vessels is described in U.S. Patent No. 4,666,829. A $\beta$  is an approximately 39-43 amino acid fragment of a large membrane-spanning glycoprotein, referred to as the  $\beta$ -amyloid precursor protein (APP), encoded by a gene on the long arm of human chromosome 21. Forms of A $\beta$  longer than 43 amino acids are also contemplated herein. A $\beta$  is further characterized by its relative mobility in SDS-polyacrylamide gel electrophoresis or in high performance liquid chromatography (HPLC). A sequence for a 43-amino acid-version of A $\beta$  is:

1  
Asp Ala Glu Phe Arg His Asp Ser Gly Tyr

11  
Glu Val His His Gln Lys Leu Val Phe Phe

21  
Ala Glu Asp Val Gly Ser Asn Lys Gly Ala

31  
Ile Ile Gly Leu Met Val Gly Gly Val Val

41  
Ile Ala Thr [SEQ ID NO:1].

As used herein, A $\beta$  also refers to related polymorphic forms of A $\beta$ , including those that result from mutations in the A $\beta$  region of the APP normal gene.

**[0038]** The term "A $\beta$  fragment" as used herein refers to fragments and degradation products of A $\beta$  which are generated at low concentrations by mammalian cells. Particular A $\beta$  fragments have a molecular weight of approximately 3 kD and are presently believed to include peptides with, for example, amino acid residues 3-34, 6-27, 6-34, 6-35, 6-42, 11-34, 11-40, 17-40, 11-43 and 12-43 of A $\beta$ .

**[0039]** As used herein, the term "A $\beta$ (x $\geq$ 41)" refers to A $\beta$  whose amino-terminus begins at amino acid number 1 of A $\beta$  or which is truncated, and whose carboxy-terminus extends beyond amino acid number 40. These peptides and fragments comprise a heterogeneous group. For example, A $\beta$ (6-42), A $\beta$ (11-43) and A $\beta$ (12-43) all have been found in the CSF. However, this list is not meant to be exclusive. Other peptides from among the group are presumed to exist in the CSF and are detectable with the methods described herein.

**[0040]** The particular peptides measured from among the group of all A $\beta$ (x $\geq$ 41) depends on the particular measuring method used. In the case of using binding substances, such as antibodies, the binding substance can be directed to one or more from among the group of peptides. For example, an antibody raised against amino acids 33-42 of A $\beta$  that does not cross react with A $\beta$ (1-40) will bind to A $\beta$ (x-42). It also may bind to A $\beta$ (x-41) and A $\beta$ (x-43). According to one embodiment of the invention, the method involves determining the amount of A $\beta$ (x $\geq$ 41) having at least amino acids 13-41 of A $\beta$ . These species can be measured using a sandwich assay employing antibodies that recognize the junction region (amino acids 13-26) and antibodies produced by immunization with a hapten having A $\beta$  amino acids 33-42, as described in the Example.

**[0041]** The term "A $\beta$  junction region" as used herein refers to a region of A $\beta$  which is centered at the site between amino acid residues 16 and 17 (Lys<sup>16</sup> and Leu<sup>17</sup>) which is a target for proteolytic processing of APP. Such processing results in a variety of APP fragments which may, for example, terminate at amino acid 16 of A $\beta$  and which, therefore, are potentially immunologically cross-reactive with antibodies to the intact A $\beta$  molecule which are to be identified in the methods of the present invention. Antibodies raised against a synthetic peptide including amino acid residues 13-29 having been found to display the requisite specificity.

**[0042]** The term "amyloid- $\beta$  precursor protein" (APP) as used herein is defined as a polypeptide that is encoded by a gene of the same name localized in humans on the long arm of chromosome 21 and that includes A $\beta$  within its



carboxyl third. APP is a glycosylated, single-membrane-spanning protein expressed in a wide variety of cells in many mammalian tissues. Examples of specific isotypes of APP which are currently known to exist in humans are the 695-amino acid polypeptide described by Kang et al. (1987) Nature 325:733-736 which is designated as the "normal" APP; the 751-amino acid polypeptide described by Ponte et al. (1988) Nature 331:525-527 (1988) and Tanzi et al. (1988) Nature 331:528-530; and the 770-amino acid polypeptide described by Kitaguchi et al. (1988) Nature 331:530-532. Examples of specific variants of APP include point mutations which can differ in both position and phenotype (for review of known variant mutations see Hardy (1992) Nature Genet. 1:233-234).

**[0043]** The term "A $\beta$ -related condition" as used herein is defined as including Alzheimer's disease (which includes familial Alzheimer's disease), Down's Syndrome, HCHWA-D, and advanced aging of the brain.

**[0044]** As used herein, "tau" refers to the family of microtubule-associated proteins. The paired helical filament of neurofibrillary tangles in the brains of Alzheimer's disease patients are composed of tau protein. (See, e.g., M. Goedert et al. (1989) Neuron 3:519-526 and M. Goedert (1993) TINS 16:460-465) Goedert et al. (1989) also presents a DNA and amino acid sequence for tau.

**[0045]** The term "body fluid" as used herein refers to those fluids of a mammalian host which will be expected to contain measurable amounts of A $\beta$ , A $\beta$  fragments or tau protein, specifically including cerebrospinal fluid (CSF), blood, urine, and peritoneal fluid. The term "blood" refers to whole blood, as well as blood plasma and serum.

**[0046]** The methods and systems of this invention involve the ability to detect species of A $\beta$  extending beyond amino acid number 40 at the carboxy-terminal end and, therefore, to distinguish them from shorter species, such as A $\beta$ (40). While detection of A $\beta$ (x $\geq$ 41) can be accomplished by any methods known in the art for detecting peptides, the use of immunological detection techniques employing binding substances such as antibodies, antibody fragments, recombinant antibodies, and the like, is preferred. Particularly suitable detection techniques include ELISA, Western blotting, radioimmunoassay, and the like. Suitable immunological methods employing a single antibody are also contemplated, for example, radioimmunoassay using an antibody specific for  $\geq$  41 forms of A $\beta$ , or single antibody ELISA methods.

**[0047]** Thus, this invention also provides antibodies specific for A $\beta$ (x $\geq$ 41) that do not cross react with A $\beta$ ( $\leq$ 40). These antibodies can be made by immunizing animals with synthetic peptides that include amino acids beyond number 40 of A $\beta$ . For example, the synthetic peptide can include amino acids 33-42. A specific example of the production of such an antibody is provided in the Experimental section.

**[0048]** According to one embodiment of the invention, detection and measurement of A $\beta$ (x $\geq$ 41) peptides involves the use of two antibodies, one specific for an epitope containing amino acids beyond number 40 in A $\beta$ , and another antibody capable of distinguishing A $\beta$  and A $\beta$  fragments from other APP fragments which might be found in the sample. In particular, it has been found that antibodies which are monospecific for the junction region of A $\beta$  are capable of distinguishing A $\beta$  from other APP fragments. The junction region of A $\beta$  is centered at amino acid residues 16 and 17, typically spanning amino acid residues 13-26, and such junction-specific antibodies may be prepared using synthetic peptides having that sequence as an immunogen.

**[0049]** A preferred immunoassay technique is a two-site or "sandwich" assay employing a junction-specific antibody as the capture antibody (bound to a solid phase) and a second antibody which binds to an epitope containing amino acids beyond number 40 in A $\beta$ . Particular methods for preparing such antibodies and utilizing such antibodies in an exemplary ELISA are set forth in the Experimental section hereinafter and in related United States patent application 07/965,972, *supra*.

**[0050]** Antibodies specific for A $\beta$  may be prepared against a suitable antigen or hapten comprising the desired target epitope, such as the junction region consisting of amino acid residues 13-29 and the carboxy terminus consisting of amino acid residues 33-42. Conveniently, synthetic peptides may be prepared by conventional solid phase techniques, coupled to a suitable immunogen, and used to prepare antisera or monoclonal antibodies by conventional techniques. Suitable peptide haptens will usually comprise at least five contiguous residues within A $\beta$  and may include more than six residues.

**[0051]** Synthetic polypeptide haptens may be produced by the well-known Merrifield solid-phase synthesis technique in which amino acids are sequentially added to a growing chain (Merrifield (1963) J. Am. Chem. Soc. 85:2149-2156). The amino acid sequences may be based on the sequence of A $\beta$  set forth above.

**[0052]** Once a sufficient quantity of polypeptide hapten has been obtained, it may be conjugated to a suitable immunogenic carrier, such as serum albumin, keyhole limpet hemocyanin, or other suitable protein carriers, as generally described in Hudson and Hay, *Practical Immunology*, Blackwell Scientific Publications, Oxford, Chapter 1.3, 1980. An exemplary immunogenic carrier utilized in the examples provided below is  $\alpha$ -CD3 $\epsilon$  antibody (Boehringer-Mannheim, Clone No. 145-2C11).

**[0053]** Once a sufficient quantity of the immunogen has been obtained, antibodies specific for the desired epitope may be produced by *in vitro* or *in vivo* techniques. *In vitro* techniques involve exposure of lymphocytes to the immunogens, while *in vivo* techniques require the injection of the immunogens into a suitable vertebrate host. Suitable vertebrate hosts are non-human, including mice, rats, rabbits, sheep, goats, and the like. Immunogens are injected into the animal according to a predetermined schedule, and the animals are periodically bled, with successive bleeds

having improved titer and specificity. The injections may be made intramuscularly, intraperitoneally, subcutaneously, or the like, and an adjuvant, such as incomplete Freund's adjuvant, may be employed.

**[0054]** If desired, monoclonal antibodies can be obtained by preparing immortalized cell lines capable of producing antibodies having desired specificity. Such immortalized cell lines may be produced in a variety of ways. Conveniently, a small vertebrate, such as a mouse, is hyperimmunized with the desired immunogen by the method just described. The vertebrate is then killed, usually several days after the final immunization, the spleen cells removed, and the spleen cells immortalized. The manner of immortalization is not critical. Presently, the most common technique is fusion with a myeloma cell fusion partner, as first described by Kohler and Milstein (1975) *Nature* 256:495-497. Other techniques including EBV transformation, transformation with bare DNA, e.g., oncogenes, retroviruses, etc., or any other method which provides for stable maintenance of the cell line and production of monoclonal antibodies. Specific techniques for preparing monoclonal antibodies are described in *Antibodies: A Laboratory Manual*, Harlow and Lane, eds., Cold Spring Harbor Laboratory, 1988.

**[0055]** In addition to monoclonal antibodies and polyclonal antibodies (antisera), the detection techniques of the present invention will also be able to use antibody fragments, such as F(ab), Fv, V<sub>L</sub>, V<sub>H</sub>, and other fragments. In the use of polyclonal antibodies, however, it may be necessary to adsorb the anti-sera against the target epitopes in order to produce a monospecific antibody population. It will also be possible to employ recombinantly produced antibodies (immunoglobulins) and variations thereof as now well described in the patent and scientific literature. See, for example, EPO 8430268.0; EPO 85102665.8; EPO 85305604.2; PCT/GB 85/00392; EPO 85115311.4; PCT/US86/002269; and Japanese application 85239543. It would also be possible to prepare other recombinant proteins which would mimic the binding specificity of antibodies prepared as just described.

**[0056]** Detection of tau also can be accomplished by any methods known in the art for detecting peptides. However, the use of immunological detection techniques employing binding substances is preferred. Useful detection techniques include all those mentioned above. ELISA assays involving a capture antibody and a labeled detection antibody, both against tau, are particularly useful.

**[0057]** Antibodies against tau can be prepared by inoculating animals with tau purified from AD brains or from recombinant sources. Recombinant tau can be produced by expression in insect cells from a baculovirus vector containing pVL941-tau-4 repeat isoform as described by J. Knops et al. (1991) *J Cell Biol* 1991:114:725-733. Purified tau also is available from Immogenetics (Zwijndrecht, Belgium). Antibodies against tau are available from Sigma (St. Louis, MO). Additional sources can be identified in the *Lindscott* directory.

**[0058]** Tau can be prepared from AD brain by the method of Mercken et al. (1992) *J Neurochem* 58:548. Typically, 50 g of fresh brain is cut into small pieces with scissors and homogenized 1:1 (wt/vol) in buffer A (20 mM 2-[N-morpholino]ethanesulfonic acid, 80 mM NaCl, 2 mM EDTA, 0.1 mM EGTA, 1 mM MgCl<sub>2</sub>, and 1 mM β-mercaptoethanol, pH 6.75) with a Potter homogenizer equipped with a Teflon plunger. The homogenate is centrifuged for 1 hour at 150,000 g at 4° C, and the supernatant is heated for 5 minutes in boiling water and chilled again for 10 minutes on ice. The slurry is centrifuged for 2 hours at 150,000 g at 4° C, and the supernatant is collected thereafter. The heat-stable cytosolic extract is made to 2.5% perchloric acid and centrifuged for 1 hour at 150,000 g at 4° C, after which the supernatant is neutralized with 3 M Tris. The supernatant is then dialyzed and concentrated in water in a Centiprep concentrator (Amicon, Lausanne, Switzerland). The end product can be evaluated in sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) (Laemmli method). This preparation is useful for immunizing animals to produce anti-tau antibodies.

**[0059]** Tau also can be immunopurified from this preparation. Ten milligrams of anti-tau monoclonal antibody is coupled to 1 g of cyanogen bromide-activated Sepharose (Pharmacia) by the method proposed by the manufacturer. Fifty milliliters of the heat stable cytosolic extract described above is diluted 1:2 in 0.1 M phosphate buffer (pH 8.5) and applied to the column. The column is washed with 0.1 M phosphate, and tau is eluted with 0.1 M citric acid (pH 2.5) and neutralized immediately with 1 M NaOH. Fractions can be evaluated by SDS-PAGE on 10% gels and in immunoblotting with anti-tau antibodies.

**[0060]** This invention also provides kits for performing assays that aid in the diagnosis of Alzheimer's disease. The kits include means for detecting Aβ(x≥41) and means for detecting tau. The means can include any means known or described above, e.g., binding substances. Useful binding substances include molecules containing the binding portion of an antibody, such as a full antibody or an antibody fragment. The binding substances can be monoclonal antibodies. In one embodiment the kit includes a binding substance that binds Aβ(x≥41) but that does not bind to Aβ(≤40) and a binding substance that binds to tau.

**[0061]** In one embodiment the kit includes antibodies or the like for performing sandwich ELISAs to detect each compound, for example, as described above. In one embodiment, the means to detect Aβ(x≥41) can include a binding substance that binds to an epitope containing amino acids beyond number 40 in Aβ and a binding substance that binds Aβ or a fragment of Aβ but that does not bind other fragments of APP. The means to detect tau also can involve a sandwich ELISA. For example, the kit can include a) an un-labeled binding substance that binds to the junction region of Aβ; b) a detectably labelled binding substance that binds to an epitope containing amino acids beyond number 40

in A $\beta$ ; c) an un-labelled binding substance that binds to tau; and d) a detectably labelled binding substance that binds to tau.

**[0062]** The detectable labels can be any known and used in the art including, e.g., biotinylation, radioactive label, enzymes, fluorescent labels and the like.

**[0063]** Animal models are currently being used to study Alzheimer's disease. (See, e.g., International Patent Application WO 93/14200, U.S. patent application 08/143,697, filed October 27, 1993, and U.S. Patent 5,387,742.) These models are useful for screening compounds for their ability to effect the course of Alzheimer's disease, both to ameliorate and aggravate the condition. Since AD is characterized by a decrease in the amounts of A $\beta$ (x $\geq$ 41) in the CSF, it is expected that effective treatments for Alzheimer's disease will result in an increase in amount of A $\beta$ (x $\geq$ 41) in the CSF, while agents that hasten progress of the disease will result in a decrease in the amount of A $\beta$ (x $\geq$ 41) in the CSF.

**[0064]** Accordingly, this invention provides methods for screening compounds that elevate or decrease the amount of A $\beta$ (x $\geq$ 41) in a fluid sample, in particular the CSF, and that, therefore, are candidates for use in treating the disease, or that hasten the disease and are to be avoided by humans. The methods involve measuring a first amount of said one or more soluble A $\beta$ (x $\geq$ 41) in a sample of a non-human animal used as a model of Alzheimer's disease; administering the compound to the animal; measuring a second amount of one or more soluble A $\beta$ (x $\geq$ 41) in a sample of the animal; and comparing the first amount with the second amount, the difference indicating whether the compound increases, decreases, or leaves unchanged the amount of soluble A $\beta$ (x $\geq$ 41) in the sample. The dosage level given to the animal and the amount of time that elapses before measuring the second amount will, of course, depend on the model system.

**[0065]** This invention also provides methods for screening compounds that elevate the amount of A $\beta$ (x $\geq$ 41) and decrease the amount of tau in a fluid sample, particularly CSF, and that, therefore, are candidates for use in treating the disease; or that decrease the level of A $\beta$ (x $\geq$ 41) and that increase the level of tau and therefore, that hasten the disease and are to be avoided by humans. The methods involve measuring a first amount of said one or more soluble A $\beta$ (x $\geq$ 41) and tau in a fluid sample of a non-human animal used as a model of Alzheimer's disease; administering the compound to the animal; measuring a second amount of one or more soluble A $\beta$ (x $\geq$ 41) and tau in a fluid sample of the animal; and comparing the first amounts with the second amounts, the difference indicating whether the compound increases, decreases, or leaves unchanged the amount of soluble A $\beta$ (x $\geq$ 41) and tau in the fluid sample. The dosage level given to the animal and the amount of time that elapses before measuring the second amount will, of course, depend on the model system.

**[0066]** One useful non-human animal model harbors a copy of an expressible transgene sequence which encodes the Swedish mutation of APP (asparagine<sup>595</sup>-leucine<sup>596</sup>). The sequence generally is expressed in cells which normally express the naturally-occurring endogenous APP gene (if present). Mammalian models, more particularly, rodent models and in particular murine and hamster models, are suitable for this use. Such transgenes typically comprise a Swedish mutation APP expression cassette, in which a linked promoter and, preferably, an enhancer drive expression of structural sequences encoding a heterologous APP polypeptide comprising the Swedish mutation.

**[0067]** The transgenic animals that harbor the transgene encoding a Swedish mutation APP polypeptide are usually produced by introducing the transgene or targeting construct into a fertilized egg or embryonic stem (ES) cell, typically by microinjection, electroporation, lipofection, or biolistics. The transgenic animals express the Swedish mutation APP gene of the transgene (or homologously recombined targeting construct), typically in brain tissue. Preferably, one or both endogenous APP allele is inactivated and incapable of expressing the wild-type APP.

**[0068]** The following examples are offered by way of illustration, not by way of limitation.

## EXPERIMENTAL

### I. A $\beta$ (x $\geq$ 41) IS DECREASED IN ALZHEIMER'S PATIENTS

#### Materials and Methods

#### 1. Antibody Preparation.

##### *a. Monoclonal Antibodies to the A $\beta$ Junction Region.*

**[0069]** Monoclonal antibodies to the junction region of A $\beta$  were prepared using a synthetic peptide spanning amino acid residues 13-31, except that Al, amino acids 30 and 31, were substituted with GC. This peptide was called A $\beta$ <sub>13-28</sub>. A $\beta$ <sub>13-28</sub> was conjugated to an immunogen ( $\alpha$ -CD3 $\epsilon$  antibody; Clone No. 145-2C11, Boehringer-Mannheim) using m-maleimidobenzoyl-N-hydroxysuccinimide ester (MBS) according to the manufacturer's (Pierce) instructions.

**[0070]** A/J mice were immunized initially intraperitoneally (IP) with the A $\beta$  conjugate mixed with complete Freund's adjuvant. Fourteen days later, the mice were boosted IP with the A $\beta$  conjugate mixed with phosphate buffered saline

(PBS) at 14 day intervals. After six total boosts, the mice were finally boosted intravenously with A $\beta$  conjugate mixed with incomplete Freund's adjuvant and fused 3 days later. Fusion of spleen cells with P3.653 myeloma cells was performed according as described in Oi and Herzenberg, *Selective Methods in Cellular Immunology*, Mishell and Shigii, Eds., W.H. Freeman and Company, San Francisco, Chapter 17 (1980). Serum titers and initial screens were performed by the RIA method described below. Several clones were expanded to a 24-well plate and subjected to further analysis as described below. Clones of interest were produced in mouse ascites.

**[0071]** The RIA method used to screen serum bleeds and fusion hybridoma supernatants was based upon a method developed by Wang et al. (1977) J. Immunol. Methods 18:157-164. Briefly, the supernatant (or serum) was incubated overnight at room temperature on a rotator with <sup>125</sup>I-labeled A $\beta$ <sub>1-28</sub> and Sepharose® 4B beads to which sheep anti-mouse IgG had been coupled via cyanogen bromide. The beads from each well were harvested onto glass fiber filter discs with a cell harvester and washed several times with PBS. The filter discs were then transferred to gamma tubes and the bound radioactivity was counted in a gamma counter.

**[0072]** All hybridomas were tested for binding to A $\beta$ <sub>1-28</sub> using the method described above in the initial screen, and then retested 3 days later. A $\beta$ <sub>1-28</sub> positive clones were further characterized for reactivity to <sup>125</sup>I-labeled A $\beta$ <sub>1-16</sub> using the RIA method described above. No clones were found to bind A $\beta$ <sub>1-16</sub>. In a peptide capture ELISA, all clones were found to react with A $\beta$ <sub>13-28</sub> while no clones reacted to A $\beta$ <sub>17-28</sub>. Therefore, it was determined that all clones had an epitope within the junction region spanning amino acids 16 and 17.

**[0073]** Based on results of the above assays, several clones were expanded into 24 well plates. These clones were further characterized by saturation analysis. Supernatants at the 50% titer point (as determined by the RIA method described above) were added to wells containing Sepharose®-sheep anti-mouse IgG beads, a constant amount of <sup>125</sup>I-labeled A $\beta$ <sub>1-28</sub>, and varying amounts of unlabeled A $\beta$ <sub>13-28</sub> or A $\beta$ <sub>17-28</sub>. The concentration of cold peptide for 50% inhibition was determined for each antibody. For the A $\beta$ <sub>17-28</sub>, no inhibition was seen at 100 ng/well for any clones. The 50% inhibition point for A $\beta$ <sub>13-28</sub> ranged from 10-80 ng/well. The clones were also characterized based on reactivity in Western blots. Based on titer point, sensitivity (as determined by the 50% inhibition point), and reactivity on Western blot, several clones were produced in ascites. Antibodies from hybridoma designated 266 was selected for use as a capture antibody in the assays described below.

#### *b. Polyclonal Antibodies to the C-terminal Epitope Containing Amino Acids 33-42 of A $\beta$*

**[0074]** Polyclonal antibodies were generated against A $\beta$ (33-42) as follows. Peptide 277-2 (C-aminoheptanoic-GLM-VGGVVIA [SEQ ID NO:2]) was conjugated to cationized BSA (Pierce activated "Supercarrier") at a ratio of 5 mg of 277-2 peptide to 10 mg of cationized BSA as follows. One vial of Pierce Supercarrier (10 mg) was resuspended in 1 mL of deionized water. 5 mg of the 277-2 peptide was dissolved in 5 ml of 10 mM PO<sub>4</sub> pH 8.0. The 277-2 peptide was added to the Supercarrier and incubated overnight at room temperature. This was then concentrated and the EDTA removed.

**[0075]** The immunogen (500 mg of peptide equivalent) was injected subcutaneously in complete Freund's adjuvant. Rabbits received a booster of 0.2-0.5 mg after three weeks and 0.2 to 0.5 mg at two to four week intervals thereafter. Boosters were subcutaneously administered in incomplete Freund's adjuvant. Twenty-five ml of serum was collected one week after each boost. Bleeds were screened as follows. Week 7 of the rabbit bleeds were titered by serial dilution. ELISA plates were coated with A $\beta$  1-42 overnight, and then blocked with 3% gelatin. Serial dilutions of the rabbit bleeds from 1/100-1/200,000 were incubated on the plates for 2 hours at room temperature. The plates were then washed and the anti rabbit HRP was added to each well. This incubated for one hour. The plate was washed and TMB substrate was used. ELISA titer of the rabbits was 1/20,000-1/200,000.

**[0076]** The ELISA positive rabbit bleeds were then titered in a capture RIA to compare its ability to capture <sup>125</sup>I A $\beta$  (1-42) versus <sup>125</sup>I A $\beta$  (1-40). Dilutions of rabbit antiserum from 1/25-1/675 were incubated with approximately the same number of cpm's of both tracers. Protein A sepharose was used to precipitate the immune complexes and they were then counted on a Microbeta scintillation counter. 277-2 rabbit D showed the highest titer to A $\beta$ (1-42) tracer and no cross reaction with A $\beta$ (1-40) tracer. The highest titer bleeds were then subjected to affinity purification of antibodies.

**[0077]** To affinity purify anti-277-2 antibodies, a 277-2 affinity matrix was prepared as follows: three ml of sulfo-link gel (Pierce) was washed with six volumes of 50 mM Tris, 5 mM EDTA, pH 8.5. Three mg of 277-2 peptide dissolved in 0.3 ml DMSO was brought to 3 ml with 50 mM Tris, 5 mM EDTA pH 8.5. and added to the gel. After gentle mixing for 15 minutes, the column resin was washed with six volumes of 50 mM Tris, 5 mM EDTA, 0.5 M NaCl pH 8. The column resin was then washed with 16 volumes of PBS/0.05% NaN<sub>3</sub>.

**[0078]** To affinity purify the antibodies, 20 ml of high titer serum was diluted to 40 ml with PBS and an equal volume of saturated (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> was slowly added while stirring at 4°. The mixture was allowed to stir an additional 30 minutes then spun for 15 minutes at 10,000 rpm in a Beckman JA17 rotor. The pellets were resuspended in PBS, brought to a volume of 40 ml with PBS and the (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> precipitation repeated as above. The pellets were resuspended in a total of 20 ml of PBS and dialyzed overnight against PBS at 4°.

[0079] The 277-2 column was washed with 10 ml of PBS. Then the dialyzate was run over the column. The column was then washed with 50 ml of PBS. 0.1 M glycine, 0.5 M NaCl pH 2.5 was added 1 ml at a time and fractions collected. The first four fractions containing the majority of eluted protein were pooled and neutralized with 0.4 ml of 1 M Tris pH 8.0. The pool was concentrated by membrane filtration to slightly less than 2 ml. The initial column flow-through was subjected to a second chromatographic step (after first neutralizing the column and re-equilibrating it in PBS). The second affinity-purified material was similarly neutralized and concentrated, combined with the first material and then dialyzed against PBS overnight, 4°. The protein content was determined (Pierce BCA method) and these antibodies were used in ELISA experiments.

## 2. ELISA Assay.

### a. *Binding of Capture Antibody to Microtiter Wells.*

[0080] Monoclonal antibody 266 was diluted to a concentration of 10 µg/ml in a buffer containing 0.23g/L NaH<sub>2</sub>PO<sub>4</sub>·H<sub>2</sub>O, 26.2g/L Na<sub>2</sub>HPO<sub>4</sub>·7H<sub>2</sub>O, 1g/L NaN<sub>3</sub>, pH 8.5. One hundred µl/well of this solution was then dispensed in a 96 well white Dynatech Microlite 2, 96 well flat-bottomed plate. The plates were sealed and incubated overnight at room temperature. Following coating, the remaining solution was aspirated and the non-specific binding sites were blocked with 200 µL per well of (NaH<sub>2</sub>PO<sub>4</sub>·H<sub>2</sub>O) 0.2g/L, Na<sub>2</sub>HPO<sub>4</sub>·7H<sub>2</sub>O 0.8g/L, human serum albumin (HSA) crystallized and lyophilized 2.5g/L, pH 7.4. These plates were blocked by incubating for 1 hour at room temperature in the blocking solution.

### b. *Assay Protocol.*

[0081] The calibrators were prepared from a stock solution of Aβ<sub>1-42</sub>, 1µg/ml, in DMSO. In specimen diluent ((NaH<sub>2</sub>PO<sub>4</sub>·H<sub>2</sub>O) 0.2g/L, Na<sub>2</sub>HPO<sub>4</sub>·7H<sub>2</sub>O 2.16g/L, NaN<sub>3</sub> 0.5g/L, bovine serum albumin (BSA) (globulin free) 6g/L, triton x-405 0.5ml/L NaCl 8.5g/L, pH 7.4.), the highest calibrator, 1000pg/ml (10µl Aβ<sub>1-42</sub> stock (1µg/ml DMSO) in 10ml casein specimen diluent) was prepared. Sequential dilutions were made in specimen diluent to obtain 500, 250, 125, 62.5 and 31.25pg/ml concentrations of Aβ<sub>1-42</sub>.

[0082] CSF samples were prepared as follows. The CSF samples (100-500µl) were boiled for 3 minutes. The boiled samples were placed at 4°C for 10-14 hours before assaying. CSF samples are assayed undiluted. Dilutions are only made if the initial calculated value is above the highest calibrator (1000pg/ml).

[0083] One hundred µL per well calibrators or samples were applied to the microtiter plates. The plates were sealed and incubated for 1 hour at room temperature. The plates were then washed three times with washing buffer (NaCl 80 g/L, KCl 3.85 g/L, Tris-HCl 31.75 g/L, tween-20 0.5 ml/L, pH 7.5).

[0084] Anti-Aβ(33-42) (antibody 277-2) was diluted in specimen diluent to 1µg/ml and 100µl was added per well. The plate was covered and incubated for 1 hour at room temperature. The plate was washed three times with washing buffer. The alkaline phosphatase affinity purified F(ab')<sub>2</sub> fragment donkey anti-rabbit IgG (H+L) (Jackson) was diluted 1:1000 in specimen diluent. One hundred µl/well was added. The plate was covered and incubated for 1 hour at room temperature. The plate was washed three times with washing buffer, then 100µl/well of chemiluminescent substrate was added. The chemiluminescent substrate was prepared by diluting the chemiluminescent reagent, AMPPD (Tropix), and an enhancer, emerald green (Tropix), 1:1000 and 1:100 respectively in 1M diethanolemine buffer, pH 10, containing 1mM MgCl<sub>2</sub> and 0.2% NaN<sub>3</sub>. The plates were sealed and incubated for 10 to 15 minutes at room temperature. Solution was not aspirated. This time may have to be optimized for different antibody lots.

[0085] Chemiluminescence was read and expressed as relative chemiluminescence units (CLU) after 15 minutes using a Dynatech ML 1000.

## Results

### 1. Aβ(x≥41) Assay Specificity

[0086] Aβ(x≥41) ELISA does not cross-react with Aβ(1-28), (1-38), or (1-40) (Fig. 1).

### 2. Aβ(x≥41) Assay Sensitivity

[0087] The lower sensitivity limit for this assay is 31pg/ml or 3.1pg/well (0.7fmol/well) (Fig. 1).

### 3. $A\beta(x \geq 41)$ Levels in CSF

[0088]  $A\beta(x \geq 41)$  has been verified in CSF using the  $A\beta(x \geq 41)$  ELISA. On occasion, two different groups of CSF samples, designated Group A and Group B, were obtained from various sources. Sometimes, two hundred  $\mu\text{L}$  of the CSF samples were boiled for 3 minutes prior to assay (boiling was found to increase  $A\beta(x \geq 41)$  immunoreactivity in some cases). The results of this assay can be seen in Fig. 2 and Fig. 3. Table 1 summarizes these results.

TABLE I

AD DIAGNOSTICS $A\beta(x \geq 41)$ Data Groups A and B CSF			
GROUP	$A\beta 1-42(\text{pg/mL})$ CUTOFF	SENSITIVITY FOR AD*	SPECIFICITY FOR AD
Group A	$\leq 362.7$	50%	84%
	$\leq 588.0$	93.8%	50.0%
Group B	$\leq 367.4$	50%	85%
	$\leq 504.4$	97.4%	56.6%

\*Equal to specificity for detecting that an individual does not have AD.

### 4. $A\beta(x \geq 41)$ in CSF of Rodents and Dogs

[0089]  $A\beta(x \geq 41)$  immunoreactivity was also detected in CSF of guinea pigs and dogs (Table II).

TABLE II

$A\beta$ IMMUNOREACTIVITY IN THE CSF OF VARIOUS ANIMAL SPECIES			
SPECIES	TOTAL $A\beta(\text{ng/ml})$	$A\beta(x \geq 41) (\text{ng/ml})$	% $A\beta(x \geq 41)$
Guinea Pig	4.5	0.242	5.4
Dog	4.4	0.59	13.4

[0090] This sandwich ELISA demonstrates the presence of  $A\beta(x \geq 41)$  in CSF.  $A\beta(x \geq 41)$  is only a minor component of the total  $A\beta$  in CSF. The levels of  $A\beta(x \geq 41)$  in CSF are significantly lower in AD than normal and neurological controls. Taking a 50% sensitivity limit, the specificity is 93.8 for Group A and 97.4% for Group B. These two independent groups show a remarkable similarity demonstrating that measurements of  $A\beta(x \geq 41)$  in CSF have diagnostic utility.

## II. COMBINED MEASUREMENTS OF $A\beta(x \geq 41)$ AND TAU ARE HIGHLY SENSITIVE FOR ALZHEIMER'S DISEASE

### Materials and Methods

#### 1. Subjects

[0091] All subjects enrolled in this study underwent detailed clinical and neurological evaluation at university medical centers by neurologists expert in the diagnosis of dementia. Informed consent was obtained from subjects, or their guardians, as appropriate. The evaluation included medical history, physical and neurological examinations, laboratory blood tests to exclude metabolic causes of dementia, a neuroimaging study (head CT or MR within the past 3 years for demented patients and neurological controls), and detailed psychometric testing (this varied between institutions). In addition, all subjects received the following assessment instruments: the Mini-Mental State Examination (MMSE) (American Psychiatric Association, Committee on Nomenclature and Statistics: Diagnostic and Statistical Manual of Mental Disorders: Revised Third Edition, Washington D.C. Am. Psych Associ. (1987)), the Hamilton Depression Inventory (V.C. Hachinski et al. (1975) Ann Neurol 32:632-637) and the Hachinski Ischemic Index (G. McKann et al. (1984) Neurology 34:939-944). Patients with more than one dementia diagnosis, recent stroke, head trauma, or significant peripheral nervous system disorders were excluded. The following diagnostic criteria were used:

i. AD (n=37): patients met NINCDS-ADRDA guidelines for probable AD; those who met criteria for possible AD were excluded (The Lund and Manchester Groups (1994) *J Neurol Neurosurg Psychiatr* 57:416-418). All patients were community dwelling and had mild to moderate dementia.

ii. Neurological disease controls (ND; n=32): patients with non-AD dementia or degenerative disorders affecting the central nervous system. For neurological controls, a summary of clinical records was also reviewed by a second neurologist (DG) to confirm diagnoses and to ensure that co-existing AD was unlikely. Patients with frontal lobe dementia were diagnosed according to the criteria set forth by the Lund and Manchester groups (Kawasaki E.S., in: *PCR Protocols: A guide to methods and applications*. Academic Press, Inc., New York 1990 pp. 146-152).

iii. Non-demented controls (NC; n=20): Subjects were age 50 or older and lacked significant cognitive complaints, did not have functional impairment, had normal findings on neurological examination, and scored 28-30 on the MMSE. A subgroup of these controls had symptoms of depression that did not result in significant cognitive or functional impairment, and were judged not to have AD or any organic neurological condition.

**[0092]** Lumbar punctures were performed in the mornings, after an overnight fast. All CSF samples were collected into specimen tubes provided to all sites. The first 2-3 ml of CSF was analyzed for protein, glucose and cells at the local medical center laboratory, and 4.5 mL were removed from original collection tubes and added to 8 mL Sarstedt tubes containing 500  $\mu$ L buffer (containing additives such that the final CSF solution composition included: 20 mM sodium phosphate, 20 mM triethanolamine, 0.05% Triton X-100, 100 mM NaCl, 0.05% NaN<sub>3</sub>, 1 mM diethylene triamine penta acetic acid, 1 mM EGTA, pH 7.4) and frozen at -20° C until analysis. Assay operators were unaware of the subjects' diagnoses.

## 2. ApoE Genotyping

**[0093]** ApoE genotyping was performed on available blood samples, which had been collected into EDTA vacutainer tubes. Samples were prepared by the method of Kawasaki (Kawasaki ES, in: *PCR Protocols: A guide to methods and applications*, Academic Press, Inc., New York 1990 pp.146-152) and PCR analysis performed as described by Wenham (P.R. Wenham et al. (1991) *Lancet* 337:1158-1159).

## 3. Total A $\beta$ ELISA

**[0094]** Total A $\beta$  was measured in a sequential double monoclonal antibody sandwich ELISA as described in Seubert et al. (1992) *Nature* 359:325-327. Briefly, A $\beta$  in CSF was captured by monoclonal antibody 266 (specific for A $\beta$  peptide residues 13-28) which had been pre-coated in microtiter plate wells. Detection utilized a second A $\beta$  specific, biotinylated monoclonal antibody 6C6 (recognizing A $\beta$  residues 1-16), followed by reaction with an alkaline phosphatase-avidin conjugate. After incubation with the fluorogenic substrate 4-methyl-umbelliphenyl phosphate (MUP), the fluorescent product was measured using a Millipore Cytofluor 2350 fluorometer.

## 4. A $\beta$ (x $\geq$ 41) ELISA

**[0095]** A $\beta$ (x $\geq$ 41) was measured in a similarly formatted assay using 266 as the capture antibody. The reporter polyclonal antibody 277-2 was raised against a synthetic peptide which included A $\beta$  residues 33-42 (GLMVGGVVIA) [SEQ ID NO:2], with cysteine-aminoheptanoic-acid at its amino-terminus. It was conjugated through the cysteine to cationized BSA (Pierce). The antibody 277-2 was affinity purified using the synthetic peptide conjugated to Sulfa-link resin (Pierce) and reacted strongly with <sup>125</sup>I-A $\beta$ <sub>1-42</sub> as detected by precipitation of tracer. It showed no detectable cross-reactivity with A $\beta$ <sub>1-40</sub> in either immunoprecipitation or ELISA formats, indicating at least a 1,000-fold less sensitivity towards the A $\beta$ <sub>1-40</sub> peptide. Synthetic A $\beta$ <sub>1-42</sub> was used as the standard. Detection of the 277-2 reporter antibody was achieved using a donkey anti-rabbit IgG-alkaline phosphatase conjugate and the AMPPD chemiluminescent substrate with Emerald enhancer (Tropix) (C. Vigo-Pelfrey et al. (1994) *J Neurochem* 61:1965-1968).

**[0096]** To eliminate inter-assay variability as a factor in the A $\beta$ (x $\geq$ 41) analysis, all samples were run in duplicate on the same day with the same lot of standards. The intra-assay variability was less than 10%. Prior to measure, aliquots of CSF samples were heated to 100° C for three minutes and then stored at 4° overnight before assay. The heating step was found to generally increase immunoreactivity in CSF samples, independent of diagnosis, and was therefore included. It should be noted that different lots of synthetic A $\beta$ (x $\geq$ 41) generate slightly different standard values, despite being normalized by amino acid analysis. Values listed are based upon a single standard used for the entire study. Studies involving addition of synthetic A $\beta$ (x $\geq$ 41) to CSF demonstrated that measured recovery was 80  $\pm$  5%.

5. Detection of Tau by ELISAa. *Purified Tau*

**[0097]** Tau purified from human AD brain tissue and from recombinant sources were used for characterization of the assay and antibodies. Recombinant human tau was produced using the previously described baculovirus vector containing the pVL941-tau-4-repeat isoform (J. Knops et al. (1991) J Cell Biol 1991:114:725-733). High levels of tau were expressed and purified from both SF9 and high five insect cells. Maximally expressing cell cultures were harvested, washed once in PBS, and chilled on ice. The cells were then sonically disrupted in 0.1 M MES pH 6.5, 1mM EGTA, 18  $\mu$ M EDTA, 0.5 mM MgCl<sub>2</sub>, 5  $\mu$ g/ml leupeptin, 1 mM PMSF. Cell debris was removed by low speed centrifugation and the supernatant adjusted to 0.75 M NaCl, 2%  $\beta$ -mercaptoethanol. The samples were boiled 10 minutes in capped tubes, cooled in ice and clarified by centrifugation at 100,000 x g for 30 minutes. The supernatants were then adjusted to 2.5% perchloric acid and spun for 15 minutes at 13,000 x g. The pellets were subjected to a second cycle of boiling/acid precipitation and the pooled supernatants were dialyzed against 100 mM KH<sub>2</sub>PO<sub>4</sub> pH 6.9, 2 mM EDTA, 2 mM EGTA, 2 mM  $\beta$ -mercaptoethanol, 0.3 mM PMSF.

**[0098]** The recombinant tau was judged to be at least 85% pure by SDS-PAGE stained with Coomassie blue and was used without further purification. The concentrations of all tau standards were estimated by amino acid analysis. To dephosphorylate tau, an aliquot was dialyzed into 20 mM Tris-HCl pH 8.6, 2mM MgCl<sub>2</sub>, 1 mM DTT, 10  $\mu$ M ZnCl<sub>2</sub> buffer. To half of the sample, 0.1 units of alkaline phosphatase (Boehringer Mannheim) per  $\mu$ g-tau were added; the other half was similarly diluted with buffer alone and the two samples were incubated from 5 hours at 37°.

b. *Monoclonal Antibodies Against Tau*

**[0099]** Monoclonal antibodies were prepared according to a modification of the method of Kohler and Milstein (G. Kohler and C. Milstein (1975) *Nature* 256:495-497). Tau used in all injections and screening assays was purified from SF9 cells infected with the tau-containing baculovirus construct. six week old A/J mice were injected with 100  $\mu$ g of purified tau at two week intervals. Tau was emulsified in complete Freund's adjuvant for the first immunization and in incomplete Freund's adjuvant for all subsequent immunizations. Serum samples were taken three days after the third injection to assess the titer of these animals. The highest titer mouse was injected intravenously with 100  $\mu$ g of tau in 500  $\mu$ L of PBS two weeks after receiving its third injection. The myeloma fusion occurred three days later using SP2/0 as the fusion partner. Antibodies 16G7 and 8C11 were obtained from this fusion while antibodies 16B5 and 16C5 were isolated from a subsequent fusion.

**[0100]** Supernatants from wells containing hybridoma cells were screened for their ability to precipitate <sup>125</sup>I-labeled tau. Tau was radio-iodinated using immobilized glucose oxidase and lactoperoxidase according to the manufacturer's instructions (Bio-Rad). Briefly, 10  $\mu$ g of purified recombinant tau was radiolabeled with 1 mCi of Na<sup>125</sup>I to a specific activity of 20  $\mu$ Ci/ $\mu$ g protein. 16G7, 8C11, 16B5 and 16C5 were identified as the four highest affinity monoclonal antibodies specific to tau and were cloned by limiting dilution. The isotypes on all four monoclonal antibodies specific to tau were determined to be gamma 1 kappa.

c. *Tau ELISA*

**[0101]** The anti-tau monoclonal antibody 16G7 was suspended at 5  $\mu$ g/ml in TBS and 100  $\mu$ L/well coated into microtiter plates (Dynatec Microlite 2). The coating was carried out overnight at room temperature. The solution was then aspirated and the plates blocked with 0.25% casein (w/v) in phosphate buffered saline (PBS). The anti-tau antibody 16B5 was biotinylated with the N-hydroxysuccinimide ester of biotin following the manufacturer's instructions (Pierce). Samples of either 50  $\mu$ L CSF or calibrators (50  $\mu$ L of 3-1000 pg/ml human tau), were combined with 50  $\mu$ L of the biotinylated anti-tau antibody (0.75  $\mu$ g/ml in PBS-casein, 0.05% Tween 20) into the 16G7 coated wells and incubated overnight at room temperature with constant shaking. The solution was then aspirated and plates washed three times in TTBS. Streptavidin alkaline phosphatase (Boehringer-Mannheim) was diluted 1:1000 in PBS-casein, 0.05% Tween 20 and 100  $\mu$ L added to each well. After incubation for 1 hour at room temperature, the fluid was aspirated and wells washed three times. The chemiluminescent reagent, disodium 3-(4-methoxyspiro {1, 2-dioxetane-3,2'-tricyclo [3.3.1.1<sup>3,7</sup>] tdec-4-yl} phenyl phosphate (AMPPD, Tropix) and an enhancer Emerald green (Tropix) were diluted 1:1000 and 1:100 respectively in 1 M diethanolamine buffer, containing 1 mM MgCl<sub>2</sub>, 0.02% NaN<sub>3</sub>, pH 10. 100  $\mu$ L were added per well and the plates were read after 30 min. in a Dynatec ML 1000 chemiluminometer. The data reported here used human tau isolated from brain as the calibrator.



## 6. Statistical Analysis

**[0102]** Statistical analysis of data was performed by one way analysis of variance (ANOVA) using InStat, Version 1.21.

## Results

**[0103]** Comparison of the three patient groups (Table III) showed that they were well matched for age and gender. The AD group had an average MMSE of  $17.5 \pm 7.1$  indicating mild to moderate cognitive impairment. The neurological disease control group consisted of a variety of disorders including vascular dementia (4), frontal lobe dementia (7), depression (6), Parkinson's disease (3), cortico-basal ganglionic degeneration (2), cerebellar ataxia (2), progressive supranuclear palsy (1), normal pressure hydrocephalus (1), grand mal seizure (1), Bell's palsy (1), age-associated memory impairment (1), dementia with extrapyramidal signs (1), amnesic syndrome (1), cerebellar degeneration (1). The control group consisted of individuals who were free of neurological disease and were cognitively normal (Table III).

TABLE III

SUMMARY OF PATIENT PROFILES AND MEASURED PARAMETERS			
	Alzheimer's Disease (AD)	Neurological Controls (ND)	Normal Controls (NC)
n	37	32	20
Age (mean $\pm$ SD)	70 $\pm$ 9.1	66 $\pm$ 9.1	70 $\pm$ 6.2
Sex (M%/F%)	48.6/51.4	59.4/40.6	50/50
MMSE (mean $\pm$ SD)	17.5 $\pm$ 7.1	23 $\pm$ 8.2	29.5 $\pm$ 0.6
CSF A $\beta$ (mean $\pm$ SD, ng/ml)	19.0 $\pm$ 6.9	17.9 $\pm$ 6.7	21.8 $\pm$ 6.9
APOE $\epsilon$ 4 frequency <sup>1</sup>	0.58	0.26	0.21
A $\beta$ <sub>42</sub> (mean $\pm$ SD, pg/ml)	383 $\pm$ 76**	543 $\pm$ 177	632 $\pm$ 156
Tau (mean $\pm$ SD, pg/ml)	407 $\pm$ 241*	168 $\pm$ 63	212 $\pm$ 102

<sup>1</sup> ApoE genotypes were determined on 30/37 AD, 19/32 neurological 17/20 normal controls.

\*\*p<.0001 comparing AD group to either control group.

\*p<.001 comparing AD group to either control group. control and

**[0104]** Analysis of total CSF A $\beta$  levels revealed no significant differences among the different patient groups (Table III). The mean values ranged from 19.0 ng/ml in the AD group to 17.9 ng/ml in the NC group. There was significant overlap with no statistically significant differences among the groups ( $p>.05$ ). Analysis of the A $\beta$ (x $\geq$ 41) form of the peptide, however, demonstrated a reduction in the mean value in the AD group, relative to both the ND and NC subjects (383 versus 543 and 632 pg/ml respectively) that was significant at the  $p<0.0001$  level (Figure 4). The relatively small standard deviation (76 pg/ml) of the AD group was particularly striking. Conversely, some of the ND patients exhibited reduced A $\beta$ (x $\geq$ 41) in their CSF. When a cutoff was set at 505 pg/ml, 15 of 37 ND patients and only four of 23 NC fell below this level. Alternatively, of the 35 individuals that have levels of A $\beta$ (x $\geq$ 41) greater than 505 pg/ml, none was diagnosed with AD, suggesting the test is highly specific for the absence of disease. A $\beta$ (x $\geq$ 41) was measured as described in the text. All measures are the averages of duplicate determinations, variation was  $\leq 10\%$ . Samples were assigned randomly to plates and the operator was unaware of the subject diagnoses. Reference standards, present on each microtiter plate, were not significantly different between plates.

**[0105]** Tau levels in the same subjects' CSF samples were also examined. Tau measurements were performed in duplicate. To ensure consistency, several samples from previous assays were included on subsequent plates and all samples were evaluated in at least replicate measure. Replicate measures were within 15% of original values. A significant difference exists between the AD group and either control group ( $p<.001$ ). Human brain-derived tau was used as the reference standard. AD patients had a mean value of 407 pg/ml versus 168 and 212 pg/ml in neurological and normal controls, respectively (Figure 5). This difference between the AD group and the other groups is significant at  $p<0.001$ . Employing a cutoff of 312 pg/ml, individuals with values above this level had a very high likelihood of Alzheimer's disease (22/24=92%). Only one NC and one ND subject registered above this cutoff. Separate analysis of average CSF A $\beta$ , A $\beta$ (x $\geq$ 41) or tau levels obtained from each center did not reveal differences between centers that were statistically significant for any of the disease categories as revealed by one-way analysis of variance. Of particular interest was the simultaneous analysis of A $\beta$ (x $\geq$ 41) and tau measurements in the same CSF samples (Figure 6). Figure 6 is divided into four quadrants using the cutoffs for A $\beta$ (x $\geq$ 41) and tau previously described. The presence of

both elevated tau and reduced  $A\beta(x \geq 41)$  (lower-right quadrant) was highly predictive of AD (22/23 = 96%). Conversely, high  $A\beta(x \geq 41)$  and low tau (upper-left quadrant) was represented entirely by control patients (Figure 6). More than half (58.7%) of all the individuals in this study fell into one of these two quadrants. The remaining patients exhibited low  $A\beta(x \geq 41)$  and low tau levels (lower left quadrant).

**[0106]** Although the foregoing invention has been described in detail for purposes of clarity of understanding, it will be obvious that certain modifications may be practiced within the scope of the appended claims.

SEQUENCE LISTING

**[0107]**

(1) GENERAL INFORMATION:

(i) APPLICANT:

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(ii) TITLE OF INVENTION: Methods for Aiding in the Diagnosis of Alzheimer's Disease by Measuring Amyloid-Beta Peptide ( $x \geq 41$ ) And Tau

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(v) COMPUTER READABLE FORM:

(A) MEDIUM TYPE: Floppy disk  
(B) COMPUTER: IBM PC compatible  
(C) OPERATING SYSTEM: PC-DOS/MS-DOS  
(D) SOFTWARE: PatentIn Release #1.0, Version #1.25

(vi) CURRENT APPLICATION DATA:

(A) APPLICATION NUMBER:  
(B) FILING DATE: April 7, 1995  
(C) CLASSIFICATION:

(viii) ATTORNEY/AGENT INFORMATION:

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(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 43 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

10 (ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

15           **Asp Ala Glu Phe Arg His Asp Ser Gly Tyr Glu Val His His Gln Lys**  
              1                               5                               10                               15  
              **Leu Val Phe Phe Ala Gly Asp Val Gly Ser Asn Lys Gly Ala Ile Ile**  
  20                               25                               30  
20           **Gly Leu Met Val Gly Gly Val Val Ile Ala Thr**  
  35                               40

(2) INFORMATION FOR SEQ ID NO:2:

25 (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids  
(B) TYPE: amino acid  
30 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

35                               **Gly Leu Met Val Gly Gly Val Val Ile Ala**  
  1                               5                               10

40

**Claims**

1. A method useful as a part of a diagnostic procedure for Alzheimer's disease in a patient, said method comprising:

- 45           measuring the amount of one or more soluble  $A\beta(x \geq 41)$  in a patient body fluid sample;  
              comparing the measured amount with a predetermined indicator value of said one or more soluble  $A\beta(x \geq 41)$ ,  
              optionally wherein the predetermined indicator value is measured from the same patient at an earlier time and  
              the method provides for monitoring;  
50           assessing patient status based on a difference between the measured amount and the predetermined indicator  
              value; and

              wherein a measured amount above the indicator value provides a negative indication in the diagnosis of  
Alzheimer's disease and a measured amount at or below the indicator value provides a positive indication in the  
55           diagnosis of Alzheimer's disease.

2. A method as claimed in claim 1, wherein the patient sample is cerebrospinal fluid and the indicator value is between  
about 0.45 ng/ml and about 0.7 ng/ml, preferably about 0.5 ng/ml, optionally wherein the  $A\beta(x \geq 41)$  measured

contain at least A $\beta$  amino acids 33-41.

3. A method as claimed in claim 1, wherein the patient sample is plasma.

4. A method as claimed in any of claims 1 to 3, wherein the amount of soluble A $\beta$ (x $\geq$ 41) is measured by exposing the patient sample to a first antibody or fragment thereof specific for a junction region on A $\beta$  or A $\beta$  fragment spanning amino acid residues 13 to 26 and detecting binding between the first antibody or fragment thereof and the soluble A $\beta$ (x $\geq$ 41) by exposing the patient sample to a second antibody or fragment thereof specific for A $\beta$ (x $\geq$ 41), preferably wherein

(a) the second antibody or fragment thereof recognises an epitope on A $\beta$  having amino acid residues 33-42, and/or

(b) the first antibody or fragment thereof recognises an epitope on A $\beta$  having amino acid residues 13-26.

5. A method as claimed in claim 4, wherein binding of the first antibody or fragment thereof and the soluble A $\beta$ (x $\geq$ 41) is detected by separating bound complexes of the first antibody or fragment thereof and A $\beta$ s or A $\beta$  fragments, exposing the separated bound complexes to a labeled second antibody or fragment thereof specific for A $\beta$ (x $\geq$ 41), and detecting the presence of label on the bound complexes.

6. A method as claimed in claim 1, wherein the amount of soluble amyloid- $\beta$  peptide (x $\geq$ 41) (A $\beta$ (x $\geq$ 41)) in the patient sample, optionally cerebrospinal fluid, is measured by:

capturing soluble A $\beta$ (x $\geq$ 41) from the sample using a first antibody or fragment thereof specific for a junction region on A $\beta$  spanning amino acid residues 13 to 26; and

detecting capture of soluble A $\beta$ (x $\geq$ 41) using a labeled second antibody or fragment thereof specific for A $\beta$ (x $\geq$ 41).

7. A method as claimed in claim 6, wherein the soluble A $\beta$ (x $\geq$ 41) is captured on a solid phase, and the capture is detected by exposing the solid phase to the labeled second antibody or fragment thereof and thereafter detecting the presence of the label on the solid phase.

8. A method for screening a compound to determine its ability to alter the amount of A $\beta$ (x $\geq$ 41) in the CSF comprising:

measuring a first amount of one or more soluble A $\beta$ (x $\geq$ 41) in the CSF of a non-human animal used as a model of Alzheimer's disease;

administering the compound to the non-human animal;

measuring a second amount of said one or more soluble A $\beta$ (x $\geq$ 41) in the CSF of the non-human animal; and comparing the first amount with the second amount,

the difference indicating whether the compound increases, decreases or leaves unchanged the amount of soluble A $\beta$ (x $\geq$ 41) in the CSF, wherein a compound that increases the amount of A $\beta$ (x $\geq$ 41) in the CSF might be useful in the treatment of Alzheimer's disease, and a compound that decreases the amount of A $\beta$ (x $\geq$ 41) might aggravate or hasten Alzheimer's disease.

9. A method useful as a part of a diagnostic procedure for Alzheimer's disease in a patient, said method comprising:

measuring the amount of one or more soluble A $\beta$ (x $\geq$ 41) in a patient body fluid sample;

comparing the measured amount of the soluble A $\beta$ (x $\geq$ 41) with a predetermined indicator amount of the soluble A $\beta$ (x $\geq$ 41),

measuring the amount of tau in the patient sample;

comparing the measured amount of tau with a predetermined indicator value of tau; and

assessing patient status based on a difference between the measured amounts and predetermined indicator values of A $\beta$ (x $\geq$ 41) and tau, wherein a measured amount at or below the A $\beta$ (x $\geq$ 41) indicator value and at or above the tau indicator value provides a positive indication in the diagnosis of Alzheimer's disease, and wherein a measured amount above the A $\beta$ (x $\geq$ 41) indicator value and below the tau indicator value provides a negative indication in the diagnosis of Alzheimer's disease.

10. A method as claimed in claim 9, wherein the patient sample is cerebrospinal fluid, the indicator value for A $\beta$ (x $\geq$ 41) is between about 0.45 ng/ml and about 0.7 ng/ml, preferably about 0.5 ng/ml and the indicator value for tau

is between about 0.25 ng/ml and about 0.4 ng/ml, preferably about 0.3 ng/ml, optionally wherein the A $\beta$ (x $\geq$ 41) measured contain at least A $\beta$  amino acids 33-41.

11. A method as claimed in claim 9, wherein the patient sample is plasma.

12. A method as claimed in any of claims 9 to 11, wherein the amount of soluble A $\beta$ (x $\geq$ 41) is measured by exposing the patient sample to a first antibody or fragment thereof specific for a junction region on A $\beta$  or A $\beta$  fragment spanning amino acid residues 13 to 26 and detecting binding between the first antibody or fragment thereof and the soluble A $\beta$ (x $\geq$ 41) by exposing the patient sample to a second binding substance specific for A $\beta$ (x $\geq$ 41).

13. A method as claimed in claim 12, wherein

(a) the second antibody or fragment thereof is an antibody recognising an epitope on A $\beta$  having amino acid residues 33-42, and/or

(b) the first antibody or fragment thereof is an antibody recognising an epitope on A $\beta$  having amino acid residues 13-26.

14. A method as claimed in claim 12 or claim 13, wherein binding of the first antibody or fragment thereof and the soluble A $\beta$ (x $\geq$ 41) is detected by separating bound complexes of the antibody or fragment thereof and the A $\beta$ s or A $\beta$  fragments, exposing the separated bound complexes to a labeled second antibody or fragment thereof specific for A $\beta$ (x $\geq$ 41), and detecting the presence of label on the bound complexes.

15. A method for screening a compound to determine its ability to alter the amount of both A $\beta$ (x $\geq$ 41) and tau in the CSF comprising:

measuring a first amount of one or more soluble A $\beta$ (x $\geq$ 41) in the CSF of a non-human animal used as a model of Alzheimer's disease;

measuring a first amount of tau in the CSF of the non-human animal;

administering the compound to the non-human animal;

measuring a second amount of said one or more soluble A $\beta$ (x $\geq$ 41) in the CSF of the non-human animal;

measuring a second amount of tau in the CSF of the non-human animal; and

comparing the first amounts with the second amounts,

the difference indicating whether the compound increases, decreases, or leaves unchanged the amount of soluble A $\beta$ (x $\geq$ 41) and increases, decreases, or leaves unchanged the amount of tau in the CSF, wherein a compound that increases the amount of A $\beta$ (x $\geq$ 41) and decreases the amount of tau in the CSF might be useful in the treatment of Alzheimer's disease, and a compound that decreases the amount of A $\beta$ (x $\geq$ 41) and increases the amount of tau might aggravate or hasten Alzheimer's disease.

16. A method as claimed in claim 8 or claim 15, wherein the non-human animal is a rodent, preferably a mouse.

17. A kit comprising an antibody or fragment thereof that binds A $\beta$ (x $\geq$ 41) but that does not bind to A $\beta$ ( $\leq$ 40) and an antibody or fragment thereof that binds to tau, optionally further comprising an antibody or fragment thereof that binds A $\beta$  or a fragment of A $\beta$  but that does not bind other fragments of APP.

18. A kit as claimed in claim 17, wherein the antibody or fragment thereof that binds A $\beta$ (x $\geq$ 41) but that does not bind to A $\beta$ ( $\leq$ 40) binds to an epitope containing amino acids beyond number 40 in A $\beta$  and the antibody or fragment thereof that binds A $\beta$  or a fragment of A $\beta$  but that does not bind other fragments of APP binds to a junction region on A $\beta$  spanning amino acid residues 13 to 26.

19. A kit as claimed in claim 18 comprising

(a) an un-labeled antibody or fragment thereof that binds to a junction region of A $\beta$  spanning amino acid residues 13 to 26;

(b) a detectably labeled antibody or fragment thereof that binds to an epitope containing amino acids beyond number 40 in A $\beta$ ;

(c) an un-labeled antibody or fragment thereof that binds to tau; and

(d) a detectably labeled antibody or fragment thereof that binds to tau;

5 preferably the antibodies are monoclonal antibodies, or fragments thereof.

# Patentansprüche

10 1. Ein Verfahren verwendbar als ein Teil einer diagnostischen Prozedur für Alzheimers Krankheit an einem Patienten, besagtes Verfahren umfassend:

Messen der Menge von einem oder mehreren löslichen A $\beta$  ( $x \geq 41$ ) in einer Probe von Körperflüssigkeit eines Patienten;

15 Vergleich der gemessenen Menge mit einem vorbestimmten Indikatorwert, von besagtem einen oder mehreren löslichen A $\beta$  ( $x \geq 41$ ), worin optional der vorbestimmte Indikatorwert vom gleichen Patienten zu einer früheren Zeit gemessen wurde und das Verfahren Überwachung gewährleistet;

20 Bewerten des Zustandes des Patienten basierend auf dem Unterschied zwischen der gemessenen Menge und dem vorbestimmten Indikatorwert; und

worin eine gemessene Menge oberhalb des Indikatorwertes eine negative Indikation in der Diagnose von Alzheimers Erkrankung bereitstellt und ein gemessener Wert von oder unter dem Indikatorwert eine positive Indikation in der Diagnose von Alzheimers Erkrankung bereitstellt.

25 2. Ein Verfahren wie in Anspruch 1 beansprucht, worin die Patientenprobe eine cerebrospinale Flüssigkeit ist und der Indikatorwert zwischen ungefähr 0,45 ng/ml und ungefähr 0,7 ng/ml, vorzugsweise ungefähr bei 0,5 ng/ml liegt und worin optional der A $\beta$  ( $x \geq 41$ ) der gemessen wurde, zumindest die A $\beta$  Aminosäuren 33- 41 enthält.

30 3. Ein Verfahren wie in Anspruch 1 beansprucht, worin die Patientenprobe Plasma ist.

35 4. Ein Verfahren wie in Anspruch 1 bis 3 beansprucht, worin die Menge an löslichem A $\beta$  ( $x \geq 41$ ) gemessen wird durch Exponieren der Patientenprobe gegen erste Antikörper oder ein Fragment davon, spezifisch für die Bindungsregion auf A $\beta$  oder A $\beta$  Fragment aufspannenden Aminosäureresten 13 bis 26, und Detektieren der Bindung zwischen dem ersten Antikörper oder Fragment davon und dem löslichen A $\beta$  ( $x \geq 41$ ) durch Exponieren der Patientenprobe gegen einen zweiten Antikörper oder ein Fragment davon, spezifisch für A $\beta$  ( $x \geq 41$ ), worin vorzugsweise

40 (a) der zweite Antikörper oder Fragment davon ein Epitop von A $\beta$  erkennt, das Aminosäurereste 33-42 aufweist, und/oder

(b) der erste Antikörper oder Fragment davon eine Epitop auf A $\beta$  erkennt, das die Aminosäurereste 13-26 aufweist.

45 5. Ein Verfahren wie in Anspruch 4 beansprucht, worin das Binden des ersten Antikörpers oder Fragment davon und des löslichen A $\beta$  ( $x \geq 41$ ) detektiert wird

durch Separieren von gebundenen Komplexe des ersten Antikörpers oder Fragments davon und von A $\beta$ s oder A $\beta$ -Fragmenten, wobei diese separat gebundenen Komplexe einem gelabelten zweiten Antikörper oder Fragment davon ausgesetzt werden, spezifisch für A $\beta$  ( $x \geq 41$ ), und

50 durch Detektieren der Gegenwart des Labels auf den gebundenen Komplexen.

55 6. Ein Verfahren wie in Anspruch 1 beansprucht, worin die Menge des löslichen Amyloid- $\beta$  Peptids ( $x \geq 41$ ) (A $\beta$  ( $x \geq 41$ )) in der Patientenprobe, optional der cerebrospinalen Flüssigkeit, gemessen wird durch Einfangen des löslichen A $\beta$  ( $x \geq 41$ ) aus der Probe unter Verwendung eines ersten Antikörpers oder Fragments davon, spezifisch für eine Bindungsregion auf A $\beta$  aufspannenden Aminosäureresten 13 bis 26; und Detektieren des Einfangens von löslichen A $\beta$  ( $x \geq 41$ ) unter Verwendung eines gelabelten zweiten Antikörpers oder Fragments davon spezifisch für A $\beta$  ( $x \geq 41$ ).

7. Ein Verfahren wie in Anspruch 6 beansprucht, worin das lösliche A $\beta$  ( $x \geq 41$ ) auf einer festen Phase eingefangen wird und das Einfangen detektiert wird  
 durch Exposition der festen Phase gegenüber einem zweiten Antikörper oder Fragment davon und  
 durch anschließendes Detektieren der Gegenwart des Labels auf der festen Phase.

8. Ein Verfahren zum Screenen einer Verbindung, um deren Fähigkeit zu bestimmen, die Menge von A $\beta$  ( $x \geq 41$ ) in der CSF zu verändern; das Verfahren umfassend:

Messen einer ersten Menge von einem oder mehreren löslichen A $\beta$  ( $x \geq 41$ ) in der CSF eines nicht-menschlichen Tieres, das als Modell für Alzheimers Erkrankung verwendet wird;  
 Verabreichen der Verbindung an das nicht-menschliche Tier;  
 Messen einer zweiten Menge von besagtem einem oder mehreren löslichen A $\beta$  ( $x \geq 41$ ) in der CSF des nicht-menschlichen Tieres; und  
 Vergleich der ersten Menge mit der zweiten Menge, wobei der Unterschied anzeigt, ob die Verbindung die Menge an löslichen A $\beta$  ( $x \geq 41$ ) in der CSF vergrößert, vermindert oder unverändert lässt, wobei eine Verbindung, die die Menge von A $\beta$  ( $x \geq 41$ ) in der CSF vergrößert, verwendbar in der Behandlung von Alzheimer's Erkrankung sein kann und eine Verbindung, die die Menge von A $\beta$  ( $x \geq 41$ ) vermindert, Alzheimer's Erkrankung verschärfen oder beschleunigen kann.

9. Ein Verfahren verwendbar als ein Teil eines diagnostischen Verfahrens für Alzheimers Erkrankung in einem Patienten, wobei besagtes Verfahren folgendes umfasst:

Messen der Menge von einem oder mehreren löslichen A $\beta$  ( $x \geq 41$ ) in einer Probe einer Körperflüssigkeit in einem Patienten;

Vergleich der gemessenen Menge des löslichen A $\beta$  ( $x \geq 41$ ) mit einer vorbestimmten Indikatormenge des löslichen A $\beta$  ( $x \geq 41$ ),

Messen der Menge von Tau der Patientenprobe;

Vergleich der gemessenen Menge von Tau mit einem vorbestimmten Indikatorwert von Tau; und

Bewerten des Patientenstatus basierend auf dem Unterschied zwischen den gemessenen Mengen und den vorbestimmten Indikatorwerten von A $\beta$  ( $x \geq 41$ ) und Tau, wobei eine gemessene Menge von oder unter dem A $\beta$  ( $x \geq 41$ ) und von oder über den Tau-Indikatorwert eine positive Indikation in der Diagnose von Alzheimer's Erkrankung liefert, und wobei die gemessene Menge oberhalb des A $\beta$  ( $x \geq 41$ ) Indikatorwertes und unterhalb des Tau Indikatorwertes eine negative Indikation in der Diagnose von Alzheimers Erkrankung liefert.

10. Ein Verfahren wie in Anspruch 9 beansprucht, worin die Patientenprobe eine cerebrospinale Flüssigkeit ist, der Indikatorwert für A $\beta$  ( $x \geq 41$ ) zwischen ungefähr 0,45 ng/ml und ungefähr 0,7 ng/ml, vorzugsweise ungefähr bei 0,5 ng/ml liegt und der Indikatorwert für Tau zwischen ungefähr 0,25 ng/ml und ungefähr 0,4 ng/ml, vorzugsweise ungefähr bei 0,3 ng/ml liegt, wobei optional der gemessene A $\beta$  ( $x \geq 41$ ) zumindest die A $\beta$  Aminosäuren 33- 41 enthält.

11. Ein Verfahren wie in Anspruch 9 beansprucht, worin die Patientenprobe Plasma ist.

12. Ein Verfahren wie in den Ansprüchen 9 und 11 beansprucht, worin die Menge an löslichem A $\beta$  ( $x \geq 41$ ) gemessen wird durch

Exponieren der Patientenprobe gegen einen ersten Antikörper oder ein Fragment davon, das spezifisch für die Bindungsregion auf A $\beta$  oder A $\beta$  Fragment aufspannenden Aminosäurenresten 13 bis 26 ist, und

Detektieren der Bindung zwischen dem ersten Antikörper oder Fragment davon und dem löslichen A $\beta$  ( $x \geq 41$ ) durch Exponieren der Patientenprobe gegen einen zweiten Antikörper oder einem Fragment davon, spezifisch für A $\beta$  ( $x \geq 41$ ).

13. Ein Verfahren wie in Anspruch 12 beansprucht, wobei

a. der zweite Antikörper oder Fragment davon ein Antikörper ist, der ein Epitop von A $\beta$  erkennt, das Aminosäurereste 33-42 aufweist, und/oder

b. der erste Antikörper oder Fragment davon ein Antikörper ist, der ein Epitop von A $\beta$  erkennt, das die Aminosäurereste 13-26 aufweist.

14. Ein Verfahren wie in Anspruch 12 oder 13 beansprucht, das Binden des ersten Antikörpers oder Fragments davon und des löslichen A $\beta$  ( $x \geq 41$ ) detektiert wird durch

Separieren gebundener Komplexe des ersten Antikörpers oder Fragments davon und A $\beta$  oder A $\beta$ -Fragmenten, wobei diese separat gebundenen Komplexe einem gelabelten zweiten Antikörper oder Fragment davon ausgesetzt werden, spezifisch für A $\beta$  ( $x \geq 41$ ), und

Detektieren der Gegenwart des Labels auf den gebundenen Komplexen.

15. Ein Verfahren zum Screenen einer Verbindung, um deren Fähigkeit zu bestimmen, die Menge sowohl von A $\beta$  ( $x \geq 41$ ) als auch Tau in der CSF zu verändern, das Verfahren umfassend:

Messen einer ersten Menge von einem oder mehreren löslichen A $\beta$  ( $x \geq 41$ ) in der CSF eines nicht-menschlichen Tieres, verwendet als Modell für Alzheimers Erkrankung;

Messen einer ersten Menge von Tau in der CSF eines nicht-menschlichen Tieres;

Verabreichen der Verbindung an ein nicht-menschliches Tier;

Messen einer zweiten Menge von besagtem einen oder mehreren löslichen A $\beta$  ( $x \geq 41$ ) in der CSF des nicht-menschlichen Tieres;

Messen einer zweiten Menge von Tau in der CSF des nicht-menschlichen Tieres; und

Vergleichen der ersten Menge mit der zweiten Menge,

wobei der Unterschied anzeigt, ob die Verbindung die Menge an löslichem A $\beta$  ( $x \geq 41$ ) vergrößert, vermindert oder unverändert lässt und ob sie die Menge von Tau in der CSF vergrößert, vermindert oder unverändert lässt, wobei eine Verbindung, die die Menge an A $\beta$  ( $x \geq 41$ ) vergrößert und die Menge von Tau in einem CSF vermindert, verwendbar in der Behandlung von Alzheimers Erkrankung sein kann, und eine Verbindung, die die Menge von A $\beta$  ( $x \geq 41$ ) vermindert und die Menge von Tau vergrößert, Alzheimers Erkrankung verschlimmern oder beschleunigen kann.

16. Ein Verfahren wie in Anspruch 8 oder Anspruch 15 beansprucht, wobei das nicht-menschliche Tier ein Nager ist, vorzugsweise eine Maus.

17. Ein Kit umfassend einen Antikörper oder Fragment davon, welcher A $\beta$  ( $x \geq 41$ ) bindet, jedoch nicht A $\beta$  ( $\leq 40$ ) bindet und einen Antikörper oder Fragment davon, welcher Tau bindet, optional weiter umfassend einen Antikörper oder Fragment davon, welcher A $\beta$  oder ein Fragment von A $\beta$  bindet, jedoch nicht andere Fragmente von APP bindet.

18. Ein Kit wie in Anspruch 17 beansprucht, wobei der Antikörper oder Fragment davon, welcher A $\beta$  ( $x \geq 41$ ) bindet, jedoch nicht an A ( $\leq 40$ ) bindet, an ein Epitop, welches Aminosäuren über Nummer 40 in A $\beta$  hinaus enthält, bindet, und der Antikörper oder Fragment davon, welcher A $\beta$  oder ein Fragment von A $\beta$  bindet, jedoch nicht andere Fragmente von APP bindet, an eine Bindungsregion von A $\beta$  aufspannenden Aminosäurenresten 13 bis 26 bindet.

19. Ein Kit wie in Anspruch 18 beansprucht, umfassend

(a) einen ungelabelten Antikörper oder Fragment davon, welcher eine Bindungsregion von A $\beta$  aufspannenden Aminosäurenresten 13 bis 26 bindet;

(b) einen nachweisbar gelabelten Antikörper oder Fragment davon, welcher ein Epitop bindet, das Aminosäuren über Nummer 40 in A $\beta$  hinausgehend enthält;

(c) einen ungelabelten Antikörper oder Fragment davon, welcher an Tau bindet; und



(d) einen nachweisbar gelabelten Antikörper oder Fragment davon, welcher an Tau bindet;

vorzugsweise sind die Antikörper monoklonale Antikörper oder Fragmente davon.

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## Revendications

1. Procédé utile un tant qu'une partie d'une procédure de diagnostic de la maladie d'Alzheimer chez un patient, ledit procédé comprenant les étapes consistant à :

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mesurer la quantité d'un ou de plusieurs  $A\beta(x \geq 41)$  solubles dans un échantillon de liquide biologique d'un patient ;

comparer la quantité mesurée avec une valeur indicative prédéterminée dudit un ou desdits plusieurs  $A\beta(x \geq 41)$  solubles, facultativement dans lequel la valeur indicative prédéterminée est mesurée sur le même patient à un moment antérieur et le procédé permet une surveillance ;

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évaluer le statut du patient en se basant sur une différence entre la quantité mesurée et la valeur indicative prédéterminée ; et

dans lequel une quantité mesurée supérieure à la valeur indicative fournit une indication négative dans le diagnostic de la maladie d'Alzheimer et une quantité mesurée inférieure ou égale à la valeur indicative fournit une indication positive dans le diagnostic de la maladie d'Alzheimer.

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2. Procédé selon la revendication 1, dans lequel l'échantillon du patient est du liquide cébrospinal et la valeur indicative est comprise entre environ 0,45 ng/ml et environ 0,7 ng/ml, de préférence d'environ 0,5 ng/ml, facultativement dans lequel l' $A\beta(x \geq 41)$  mesuré contient au moins les acides aminés 33-41 d' $A\beta$ .

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3. Procédé selon la revendication 1, dans lequel l'échantillon du patient est le plasma.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel la quantité d' $A\beta(x \geq 41)$  soluble est mesurée par exposition de l'échantillon du patient à un premier anticorps ou à un fragment de celui-ci spécifique d'une région de jonction sur l' $A\beta$  ou d'un fragment de l' $A\beta$  couvrant les résidus d'acides aminés 13 à 26 et par détection de la liaison entre le premier anticorps ou un fragment de celui-ci et l' $A\beta(x \geq 41)$  soluble par exposition de l'échantillon du patient à un second anticorps ou à un fragment de celui-ci spécifique de l' $A\beta(x \geq 41)$ , de préférence dans lequel

30

(a) le second anticorps ou un fragment de celui-ci reconnaît un épitope sur l' $A\beta$  ayant les résidus d'acides aminés 33 à 42, et/ou

(b) le premier anticorps ou un fragment de celui-ci reconnaît un épitope sur l' $A\beta$  ayant les résidus d'acides aminés 13 à 26.

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5. Procédé selon la revendication 4, dans lequel la liaison entre le premier anticorps ou un fragment de celui-ci et l' $A\beta(x \geq 41)$  soluble est détectée par la séparation des complexes liés du premier anticorps ou d'un fragment de celui-ci et des  $A\beta$  ou des fragments d' $A\beta$ , par exposition des complexes liés séparés à un second anticorps marqué ou à un fragment de celui-ci spécifique de l' $A\beta(x \geq 41)$ , et par détection de la présence du marqueur sur les complexes liés.

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6. Procédé selon la revendication 1, dans lequel la quantité du peptide amyloïde  $\beta$  ( $x \geq 41$ ) ( $A\beta(x \geq 41)$ ) soluble dans l'échantillon du patient, facultativement le liquide cébrospinal, est mesurée en :

capturant l' $A\beta(x \geq 41)$  soluble de l'échantillon en utilisant un premier anticorps ou un fragment de celui-ci spécifique d'une région de jonction sur l' $A\beta$  couvrant les résidus d'acides aminés 13 à 26 ; et

détectant la capture de l' $A\beta(x \geq 41)$  soluble en utilisant un second anticorps marqué ou un fragment de celui-ci spécifique de l' $A\beta(x \geq 41)$ .

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7. Procédé selon la revendication 6, dans lequel l' $A\beta(x \geq 41)$  soluble est capturé sur une phase solide, et la capture est détectée par exposition de la phase solide au second anticorps marqué ou à un fragment de celui-ci puis par détection de la présence du marqueur sur la phase solide.

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8. Procédé de criblage d'un composé pour déterminer sa capacité à altérer la quantité d'A $\beta$ (x  $\geq$  41) dans le LCS comprenant les étapes consistant à :

mesurer une première quantité d'un ou de plusieurs A $\beta$ (x  $\geq$  41) solubles dans la LCS d'un animal non humain utilisé en tant qu'un modèle pour la maladie d'Alzheimer ;  
administrer le composé à l'animal non humain ;  
mesurer une seconde quantité dudit un ou desdits plusieurs A $\beta$ (x  $\geq$  41) solubles dans le LCS de l'animal non humain ; et  
comparer la première quantité avec la seconde quantité,  
la différence indiquant si le composé fait augmenter, diminuer ou ne modifie pas la quantité d'A $\beta$ (x  $\geq$  41) soluble dans le LCS, dans lequel un composé qui fait augmenter la quantité d'A $\beta$ (x  $\geq$  41) dans le LCS peut être utile dans le traitement de la maladie d'Alzheimer, et un composé qui fait diminuer la quantité d'A $\beta$ (x  $\geq$  41) peut aggraver ou activer la maladie d'Alzheimer.

9. Procédé utile en tant qu'une partie d'une procédure de diagnostic de la maladie d'Alzheimer chez un patient, ledit procédé comprenant les étapes consistant à :

mesurer la quantité d'un ou de plusieurs A $\beta$ (x  $\geq$  41) solubles dans le liquide biologique d'un patient ;  
comparer la quantité mesurée d'A $\beta$ (x  $\geq$  41) soluble avec une quantité prédéterminée d'A $\beta$ (x  $\geq$  41) ;  
mesurer la quantité de tau dans l'échantillon du patient ;  
comparer la quantité mesurée de tau avec une valeur indicative prédéterminée de tau ; évaluer le statut du patient en se basant sur une différence entre les quantités mesurées et les valeurs indicatives prédéterminées d'A $\beta$ (x  $\geq$  41) et de tau ;

dans lequel une quantité mesurée inférieure ou égale à la valeur indicative d'A $\beta$ (x  $\geq$  41) et supérieure ou égale à la valeur indicative de tau fournit une indication positive dans le diagnostic de la maladie d'Alzheimer, et dans lequel une quantité mesurée supérieure ou à la valeur indicative d'A $\beta$ (x  $\geq$  41) et inférieure à la valeur indicative de tau fournit une indication négative dans le diagnostic de la maladie d'Alzheimer.

10. Procédé selon la revendication 9, dans lequel l'échantillon du patient est du liquide cérébrospinal et la valeur indicative d'A $\beta$ (x  $\geq$  41) est comprise entre environ 0,45 ng/ml et environ 0,7 ng/ml, de préférence d'environ 0,5 ng/ml, et la valeur indicative de tau est comprise entre environ 0,25 ng/ml et environ 0,4 ng/ml, de préférence d'environ 0,3 ng/ml, facultativement dans lequel l'A $\beta$ (x  $\geq$  41) mesuré contient au moins les acides aminés 33-41 d'A $\beta$ .

11. Procédé selon la revendication 9, dans lequel l'échantillon du patient est du plasma.

12. Procédé selon l'une quelconque des revendications 9 à 11, dans lequel la quantité d'A $\beta$ (x  $\geq$  41) soluble est mesurée par exposition de l'échantillon du patient à un premier anticorps ou à un fragment de celui-ci spécifique d'une région de jonction sur l'A $\beta$  ou d'un fragment d'A $\beta$  couvrant les résidus d'acides aminés 13 à 26 et par détection de la liaison entre le premier anticorps ou un fragment de celui-ci et l'A $\beta$ (x  $\geq$  41) soluble par exposition de l'échantillon du patient à une seconde substance de liaison spécifique d'A $\beta$ (x  $\geq$  41).

13. Procédé selon la revendication 12, dans lequel

(a) le second anticorps ou un fragment de celui-ci reconnaît un épitope sur l'A $\beta$  ayant les résidus d'acides aminés 33 à 42, et/ou  
(b) le premier anticorps ou un fragment de celui-ci est un anticorps reconnaissant un épitope sur l'A $\beta$  ayant les résidus d'acides aminés 13 à 26.

14. Procédé selon la revendication 12 ou la revendication 13, dans lequel la liaison du premier anticorps ou d'un fragment de celui-ci et l'A $\beta$ (x  $\geq$  41) soluble est détectée par séparation des complexes liés du premier anticorps ou d'un fragment de celui-ci et des A $\beta$  ou des fragments d'A $\beta$ , par exposition des complexes liés séparés à un second anticorps marqué ou à un fragment de celui-ci spécifique d'A $\beta$ (x  $\geq$  41), et par détection de la présence de marqueur sur les complexes liés.

15. Procédé de criblage d'un composé pour déterminer sa capacité à altérer la quantité d'A $\beta$ (x  $\geq$  41) et de tau dans le LCS comprenant les étapes consistant à :

mesurer une première quantité d'un ou de plusieurs  $A\beta(x \geq 41)$  solubles dans le LCS d'un animal non humain utilisé en tant qu'un modèle pour la maladie d'Alzheimer ;  
 mesurer une première quantité de tau dans la LCS de l'animal non humain ;  
 administrer le composé à l'animal non humain ;  
 mesurer une seconde quantité dudit un ou desdits plusieurs  $A\beta(x \geq 41)$  solubles dans le LCS de l'animal non humain ;  
 mesurer une seconde quantité de tau dans le LCS de l'animal non humain; et  
 comparer les premières quantités avec les secondes quantités,

la différence indiquant si le composé fait augmenter, diminuer ou ne modifie pas la quantité d' $A\beta(x \geq 41)$  soluble et fait augmenter, diminuer ou ne modifie pas la quantité de tau dans le LCS, dans lequel un composé qui fait augmenter la quantité d' $A\beta(x \geq 41)$  et fait diminuer la quantité de tau dans le LCS peut être utile dans le traitement de la maladie d'Alzheimer, et un composé qui fait diminuer la quantité d' $A\beta(x \geq 41)$  et fait augmenter la quantité de tau peut aggraver ou activer la maladie d'Alzheimer.

16. Procédé selon la revendication 8 ou la revendication 15, dans lequel l'animal non humain est un rongeur, de préférence une souris.

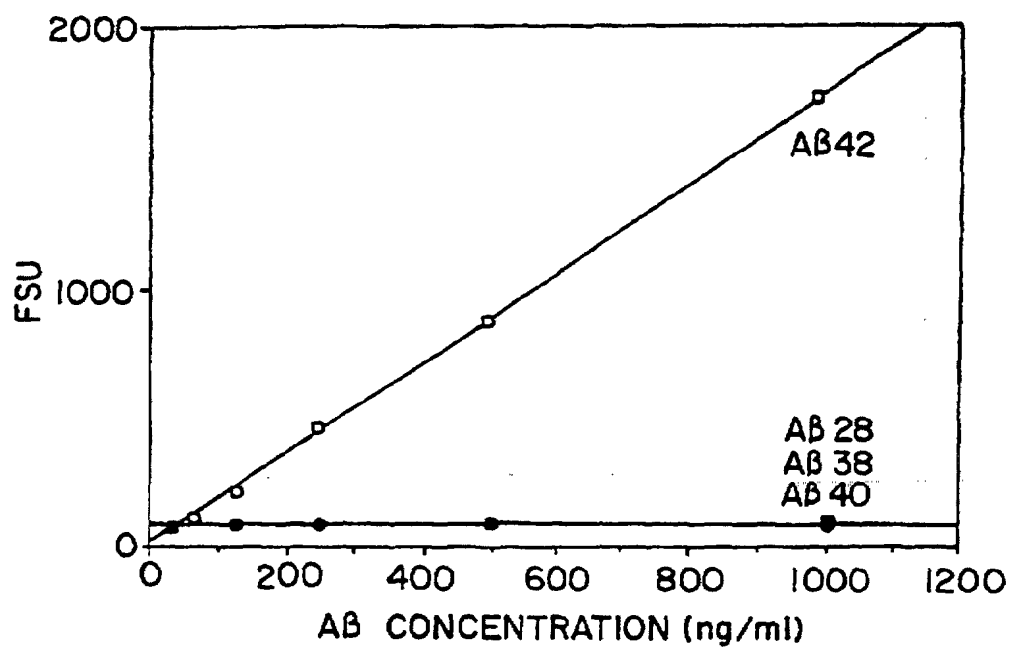
17. Kit comprenant un anticorps ou fragment de celui-ci qui se lie aux  $A\beta(x \geq 41)$  mais qui ne se lie pas aux  $A\beta(\leq 40)$  et un anticorps ou un fragment de celui-ci qui se lie à tau, comprenant facultativement en outre un anticorps ou un fragment de celui-ci qui se lie à l' $A\beta$  ou à un fragment de l' $A\beta$  mais qui ne se lie pas à d'autres fragments d'APP.

18. Kit selon la revendication 17, dans lequel l'anticorps ou le fragment de celui-ci qui se lie aux  $A\beta(x \geq 41)$  mais qui ne se lie pas aux  $A\beta(\leq 40)$  se lie à un épitope contenant des acides aminés au-delà du nombre 40 dans l' $A\beta$  et l'anticorps ou un fragment de celui-ci qui se lie à l' $A\beta$  ou à un fragment de l' $A\beta$  mais qui ne se lie pas à d'autres fragments d'APP se lie à une région de jonction sur l' $A\beta$  couvrant les résidus d'acides aminés 13 à 26.

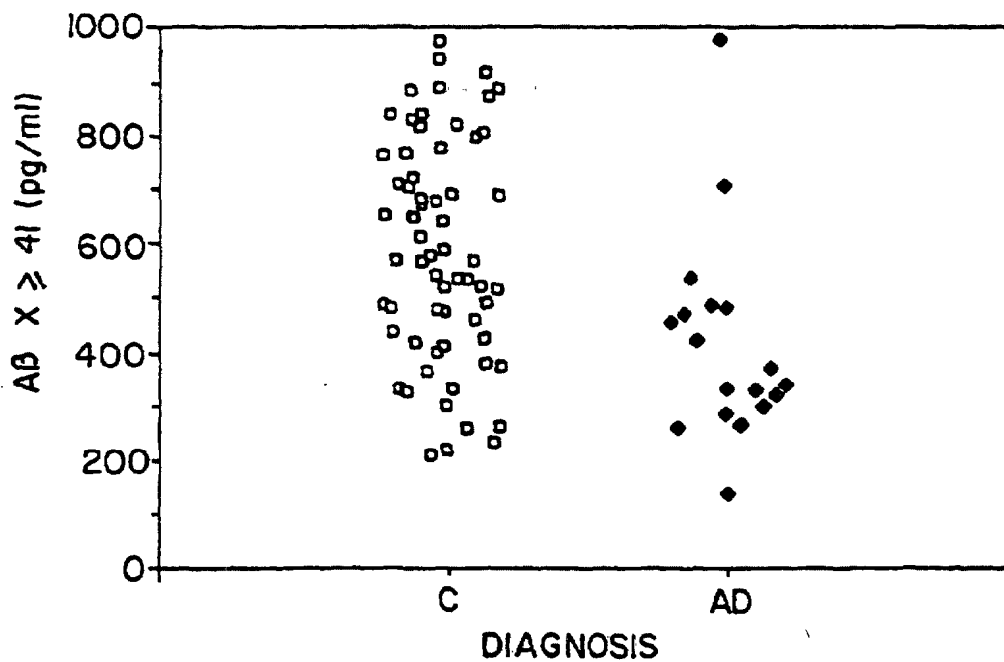
19. Kit selon la revendication 18 comprenant :

- (a) un anticorps non marqué ou un fragment de celui-ci qui se lie à une région de jonction d' $A\beta$  couvrant les résidus d'acides aminés 13 à 26 ;
- (b) un anticorps marqué de manière détectable ou un fragment de celui-ci qui se lie à un épitope contenant des acides aminés au-delà du nombre 40 dans l' $A\beta$  ;
- (c) un anticorps non marqué ou un fragment de celui-ci qui se lie à tau ; et
- (d) un anticorps marqué de manière détectable ou un fragment de celui-ci qui se lie à tau ;

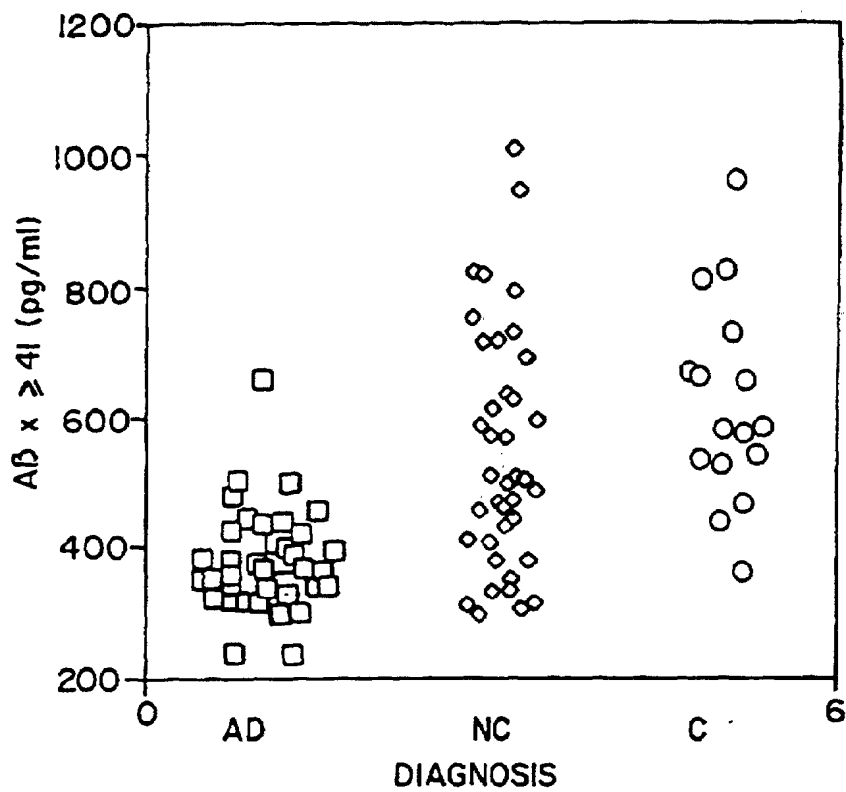
de préférence, les anticorps sont des anticorps monoclonaux, ou des fragments de ceux-ci.



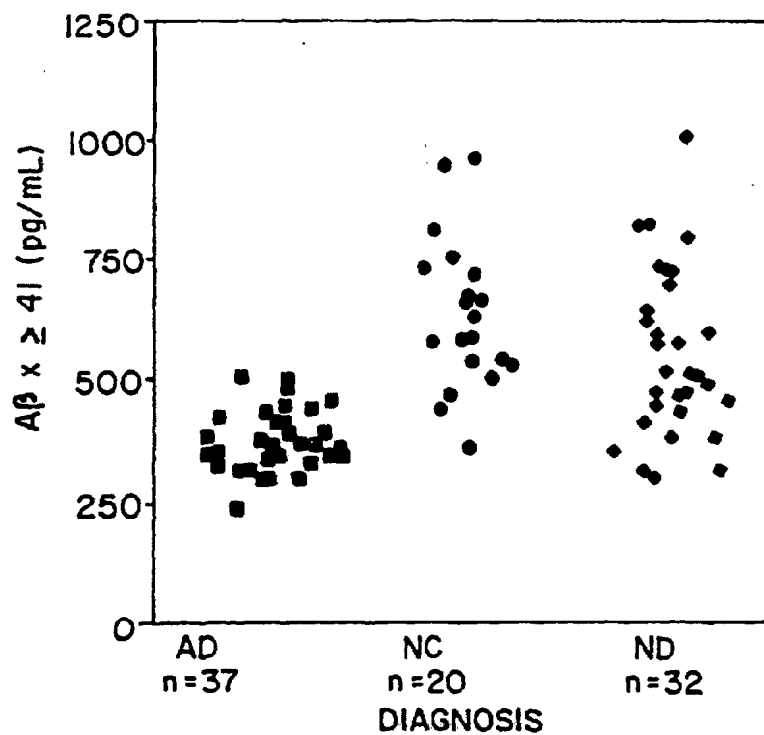
**FIG. 1.**



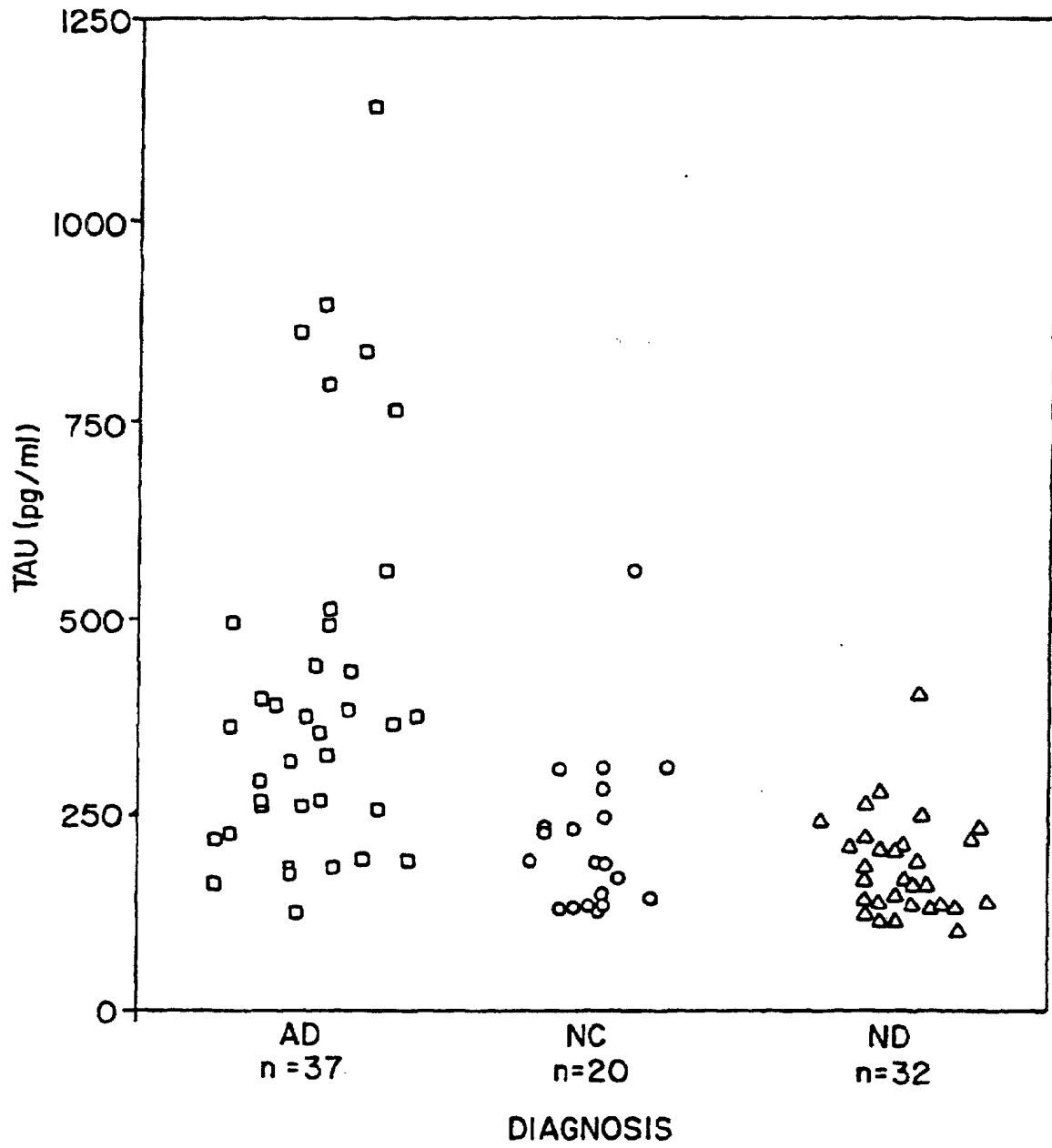
**FIG. 2.**

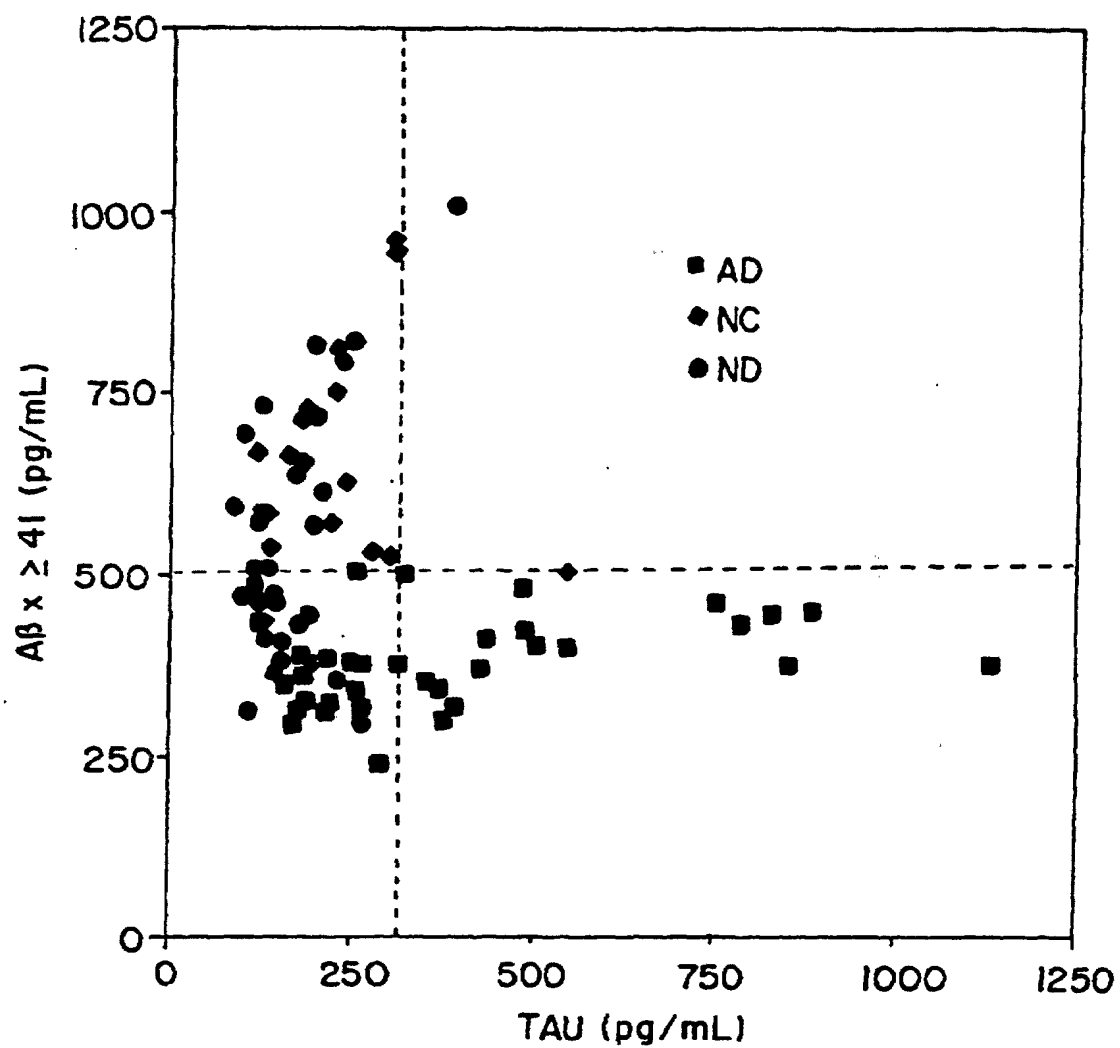


**FIG. 3.**



**FIG. 4.**

**FIG. 5.**

**FIG. 6.**